Tappi

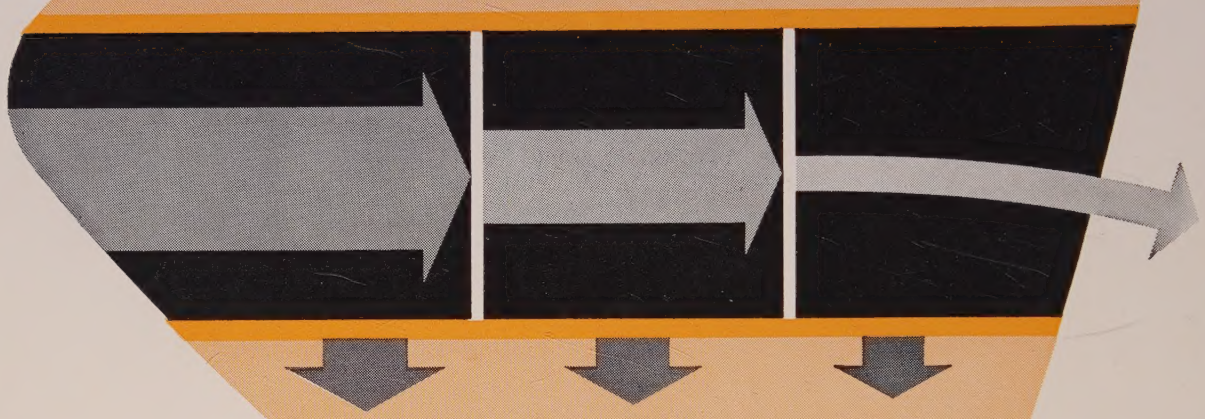
THE JOURNAL OF THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

FEBRUARY 1961

VOLUME 44 • NUMBER 2

From S. W. Hooper: a double effect design improvement in pulp screens

Cowan K-series centrifugal pulp screen operates at 100% increase in inlet consistency and a 66% decrease in fiber rejects.



In principle the new K-series screen, which in place of white water uses feed pulp as dilution in an elongated and narrowed cylinder, sharply increases the acceptance of pulp fiber for a given screen plate area.

By retaining the water-carried fiber longer within the cylinder, greater separation is accomplished.

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Saving at the outlet end: since reject fiber is reduced by two-thirds, secondary screening requirements are also reduced or eliminated.

We would like to discuss the K-series screen with you. Your letter, phone call or wire will get prompt action.

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President and
Chairman of the Board of Directors

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20-90	35-45	19.5-24	89-86
1-60	28-32	0-2	100-99
3-60	23-28	2-4	99-97.9
20-60	21-25	19.5-24	89-86
1-30	4-6	0-3	100-98.5
20-30	4-6	19.5-21.5	89-87.7
40-20	2-3	37-42	77-72.9
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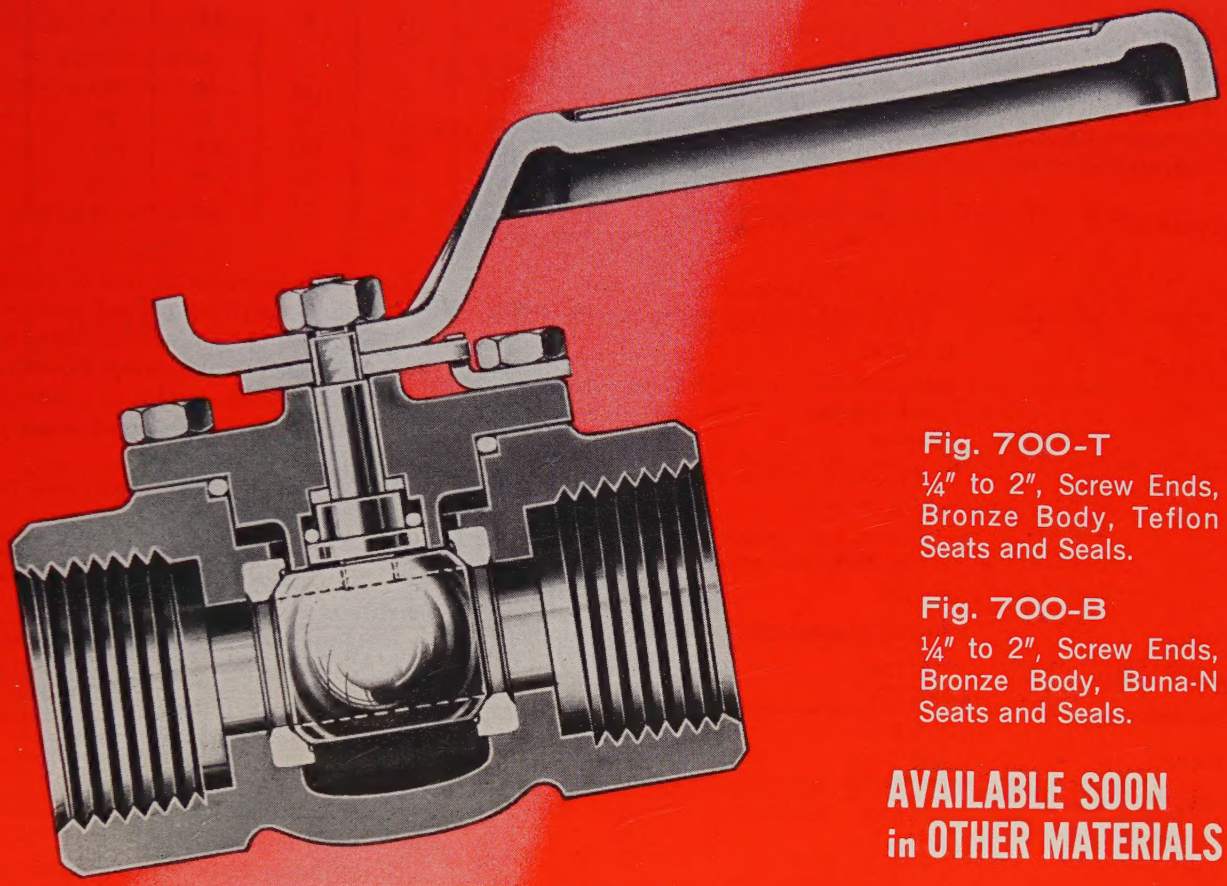

Fig. 700-T
¼" to 2", Screw Ends, Bronze Body, Teflon Seats and Seals.

Fig. 700-B
¼" to 2", Screw Ends, Bronze Body, Buna-N Seats and Seals.

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PROPERTIES IMPARTED BY VARIOUS PIGMENT COMBINATIONS IN BLEACHED SULPHITE HANDSHEETS

	75% SWW 25% TiO_2 (Control)		75% SWW 12½% TiO_2 12½% Z-23		75% SWW 17½% TiO_2 7½% Z-23		75% Sp. Hyd. 12½% TiO_2 12½% Z-23		75% Hydrafine 12½% TiO_2 12½% Z-23	
Pigment Loading Parts/100 of Pulp	4	14	4	14	4	14	4	14	4	14
PROPERTY										
Gurley Porosity, Secs./100 ml.	193	80	163	70	173	73	180	79	182	80
Gurley Softness, Secs./100 ml.	27	32	27	38	28	35	30	39	30	38
Gurley Smoothness, Secs./50 ml.	156	212	178	236	165	220	180	255	180	255
Mullen	42	27	41	26	41	26	40	26	39	25
Wax Pick (Dennison)	16	11½	16	11	16	11	15	10½	15	10

Costs were calculated as follows:

Clay—carload bulk prices per lb., F.O.B. Georgia.

SWW	0.60¢
Special Hydratex	1.10¢
Hydrafine	1.50¢

Arbitrary freight rate of 0.75¢/lb. was added to each.

Zeolex was priced at delivered cost of 7¢/lb. TiO_2 was priced at delivered cost of 25¢/lb.

PIGMENT COMBINATION	PIGMENT COST/100 LBS.	
75% SWW	$1.01	
25% TiO_2	6.25	$7.26
75% SWW	1.01	
17½% TiO_2	4.38	
7½% Zeolex	.53	5.92
75% SWW	1.01	
12½% TiO_2	3.13	
12½% Zeolex	.88	5.02
75% Special Hydratex	1.39	
12½% TiO_2	3.13	
12½% Zeolex	.88	5.40
75% Hydrafine	1.69	
12½% TiO_2	3.13	
12½% Zeolex	.88	5.70

Data [presented elsewhere in brochure] demonstrate that use of Zeolex together with an appropriate clay makes possible a considerable reduction in the use of TiO_2, thus substantially lowering the cost of pigmentation without sacrifice to sheet quality.

The foregoing tests were confined to the use of bleached sulphite pulp. However, the use of other chemical pulps or combinations of chemical pulps and ground wood yields more or less similar effects.

II. Tests on Handsheets composed principally of de-inked stock.

INGREDIENTS	FURNISH 1 With TiO_2 & Clay	FURNISH 1 With TiO_2 Zeolex & Clay	FURNISH 2 With TiO_2 & Clay	FURNISH 2 With TiO_2 Zeolex & Clay
De-inked Stocks	84.3 parts	84.3 parts	84.3 parts	84.3 parts
Virgin Pulp (chemical)	15.7 "	15.7 "	15.7 "	15.7 "
Clay, Huber SWW	2.2 "	2.2 "	12.9 "	12.9 "
TiO_2, Anatase	2.9 "	1.93 "	2.9 "	1.93 "
Zeolex	—	.97 "	—	.97 "
Rosin Size	1.0 "	1.0 "	1.0 "	1.0 "
Starch	1.0 "	1.0 "	1.0 "	1.0 "

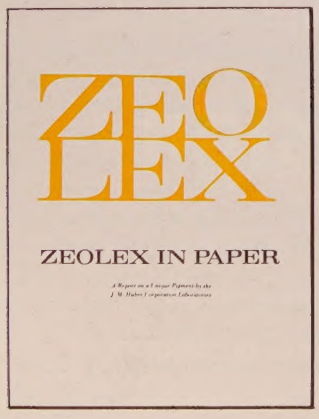
Sufficient alum was introduced to adjust furnish pH to 4.5.

Handsheets were made in accordance with TAPPI standards.

A comparison of optical properties between titanium dioxide stocks and titanium dioxide-Zeolex stocks is shown in Table IV of brochure.

Here, again, in a distinctly different application, it appears possible to replace one third of the titanium dioxide with Zeolex without appreciable change to optical qualities.

For your complete copy of this twelve-page brochure, use coupon below.



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Commodore Hotel, New York, N. Y.
Feb. 19–23, 1961

Twelfth Coating Conference
Statler-Hilton Hotel, Buffalo, N. Y.
May 8–10, 1961

Lignin Symposium
Edgewater Beach Hotel, Chicago, Ill.
Aug. 14–16, 1961

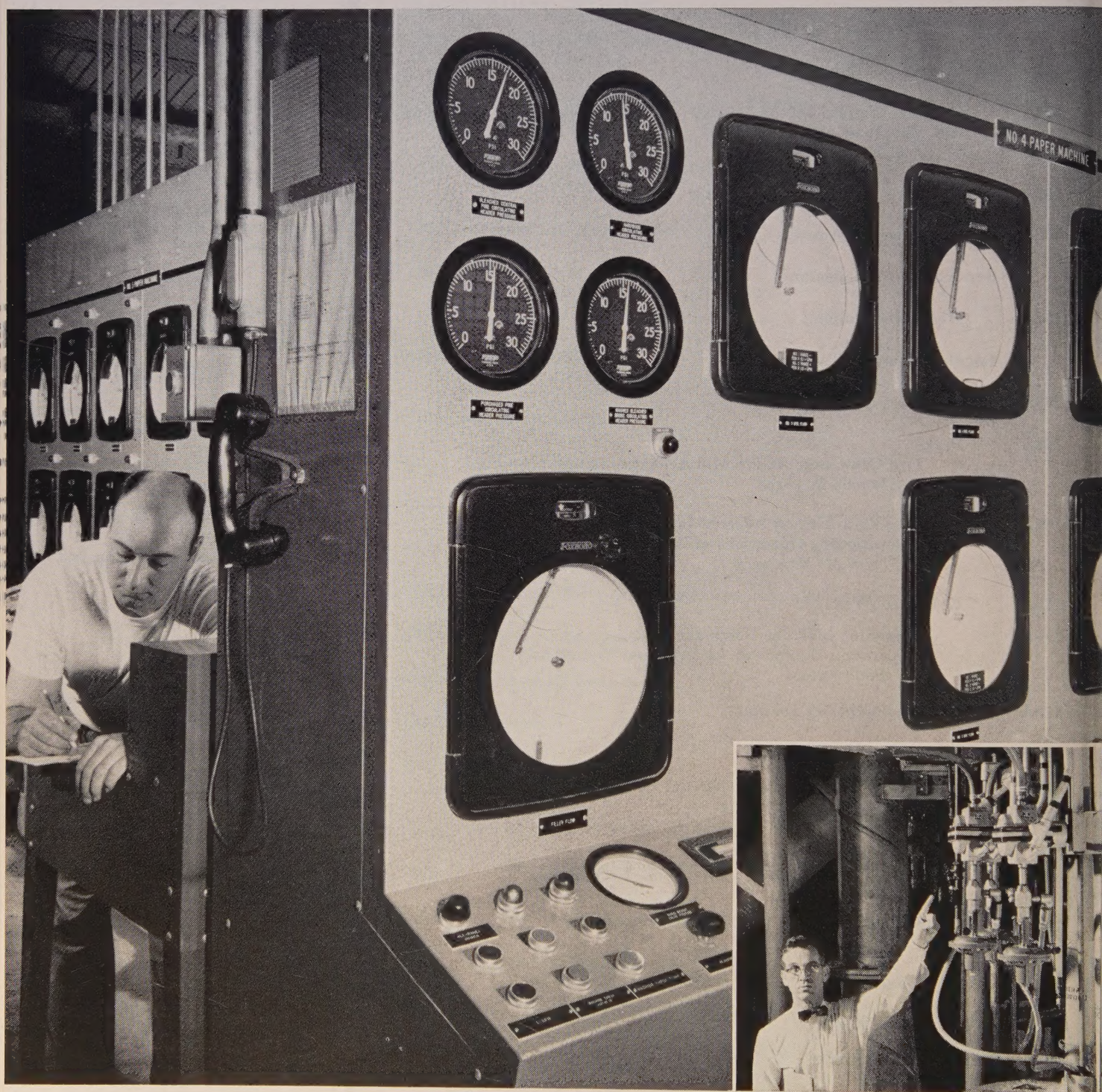
Twelfth Testing Conference
Queen Elizabeth Hotel, Montreal, Que.
Aug. 15–18, 1961

Eleventh Corrugated Containers Conference
St. Francis Hotel, San Francisco, Calif.
Sept 11–13, 1961

Fourth International Mechanical Pulping Conference
(Tech. Sect., CPPA–TAPPI)
Edgewater Beach Hotel, Chicago, Ill.
Sept. 19–21, 1961

Please refer to Local Section Activities for the locations and dates of Section meetings

at S. D. Warren Company's Foxboro Stock increase



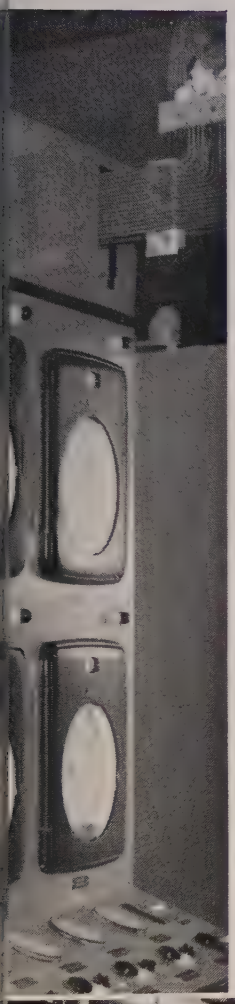
All four paper machines at Central Mill are equipped with Foxboro Stock Blending Systems. Control panels for Machines 3 and 4 are shown above. Machine superintendents report that because the Foxboro systems require less down time between runs, over-all production has been increased. Engineers and contractors for this program were Sumner Sollitt Company, Chicago.

Foxboro Magnetic Meters, 1/10 in., 3/16 in., and 1/2 in. diameter, control dye flows to mixing hoppers above each paper machine. Quick-disconnect hose permits using same meters to serve several dye distribution headers. Dye proportions are set at control panel.

PHOTOGRAPHY BY JOHN W. MOORE, JR. — PITTSBURGH

Central Mill

Blending Systems cut waste, production of first quality paper



batch beaters eliminated . . . stock, dyes, additives blended continuously, automatically

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Foxboro Stock Blending Systems were installed on all four of Central Mill's Paper Machines as a major step in their continuing modernization program. Installation was handled by Foxboro during normal down-time periods so no production time would be lost.

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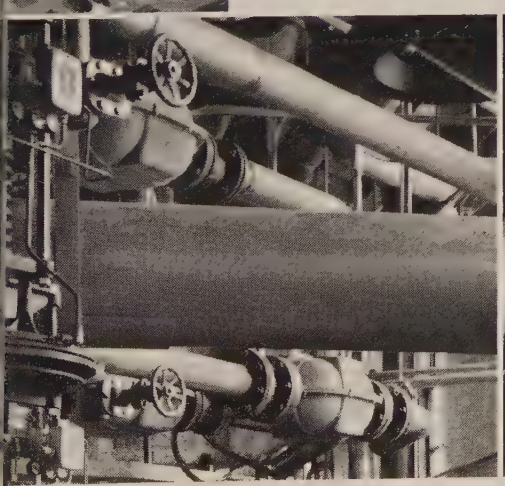
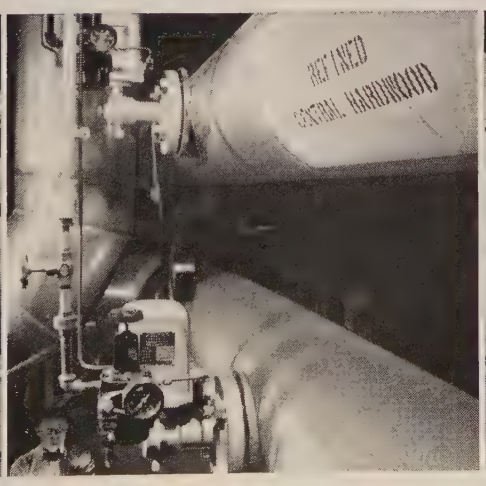
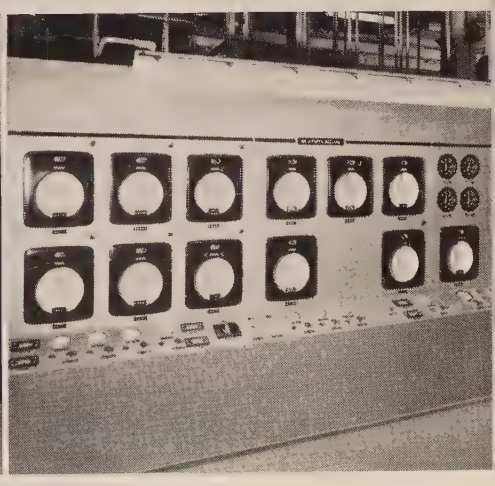


Foxboro Magnetic Meters, 3 and 4 in. diameter, control flow of stocks to blending chests — completely eliminate the need for batch beaters. Magnetic Flow Meters have no flow restriction of any type — cannot foul or plug up. Measurement is linear — accuracy guaranteed within ± 1%.

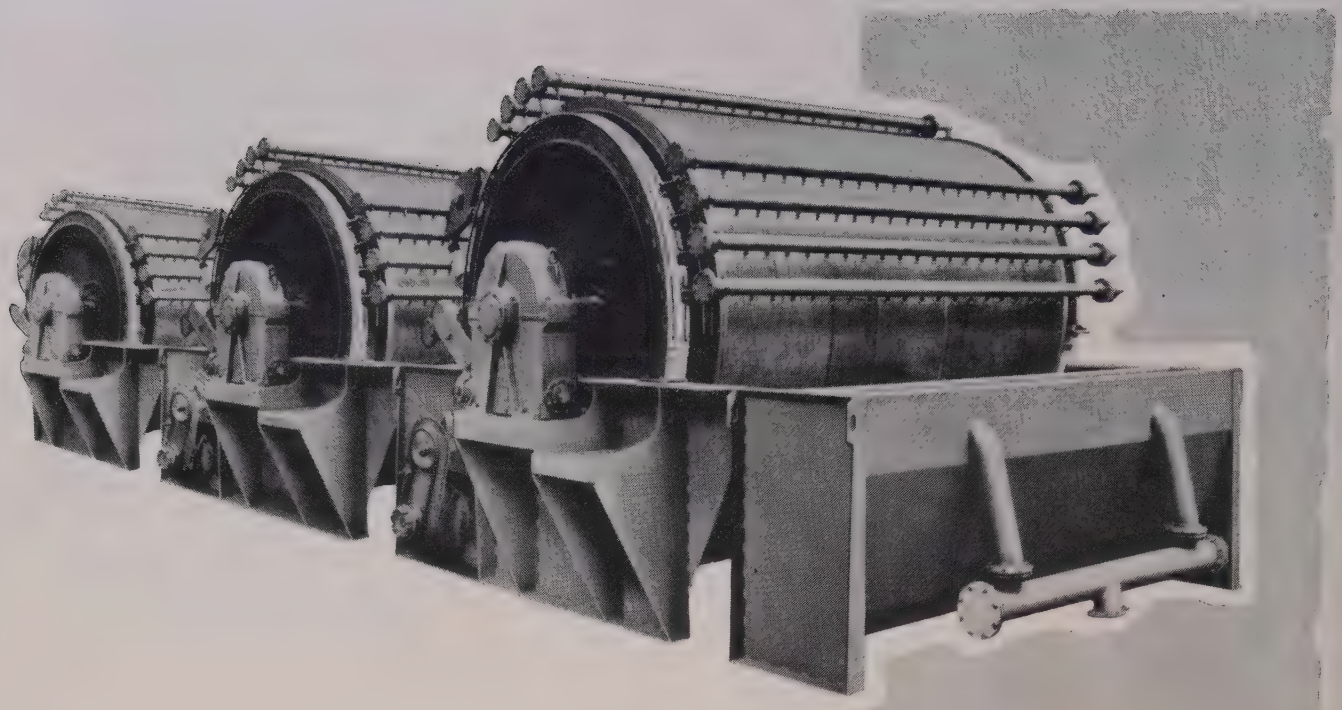


Foxboro d/p Cell* pressure transmitters are mounted right in the side of main feed-stock headers at the S D. Warren Mill. Precise operation of this entire blending system is assured by the accuracy and reliability of these sensitive pressure transmitters.

**Reg. U.S. Pat. Off.*



Foxboro instrument panel for #2 Machine gives operator complete control of the blending operation. On it are mounted flow-proportioning controllers for four stocks as well as for dyes and additives. Also, the percentage setting dials which proportion each stream to total system flow.



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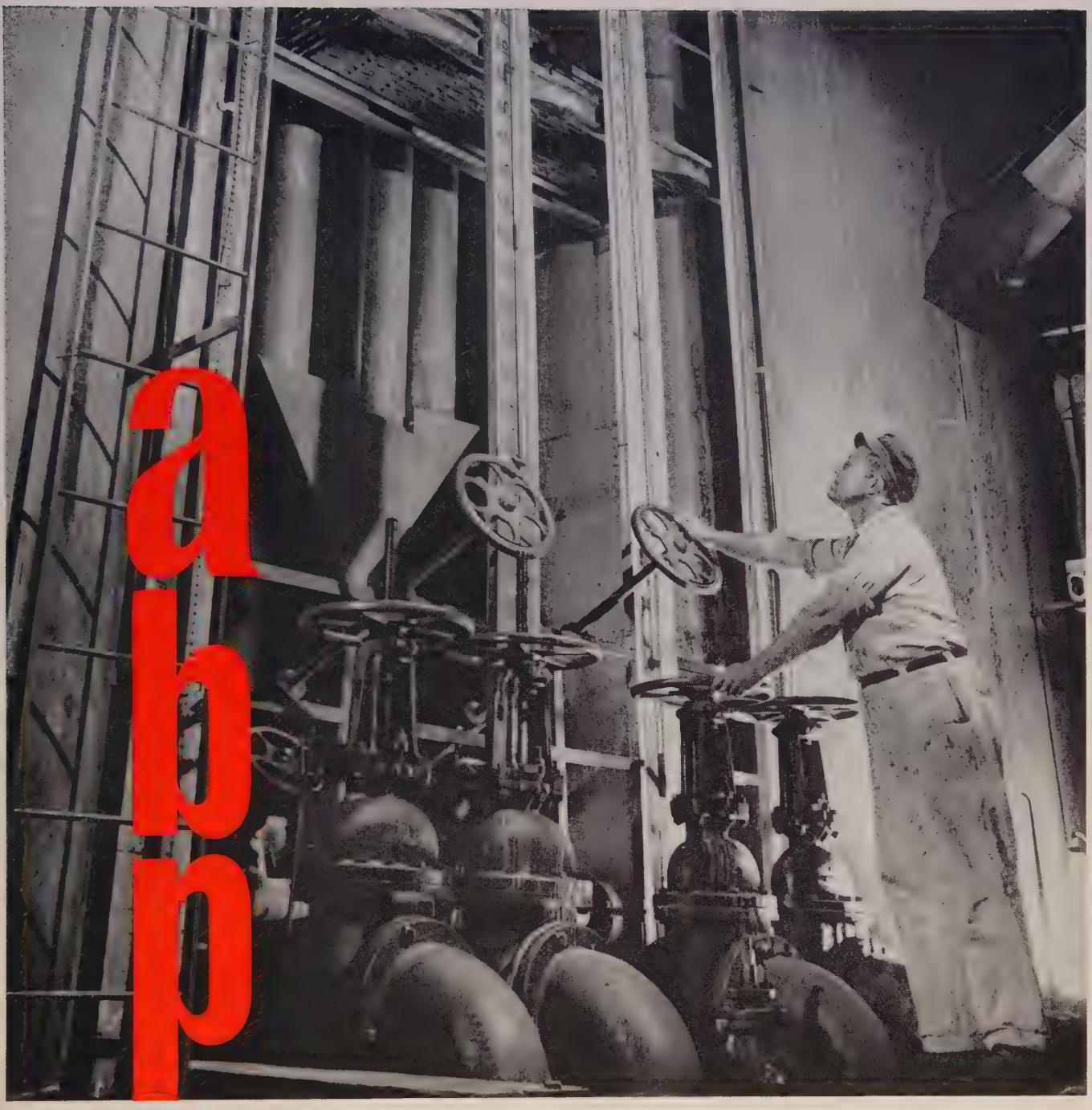

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2819

Forecast of 1961 Paper Production

LOUIS T. STEVENSON

THE paper industry is essentially a service industry and consequently reflects changes that occur in the course of the business cycle. However, since paper is, broadly speaking, a one-time-use commodity classified as nondurable, its fluctuations are minor as compared with steel and other durable goods. The top two graphs in Fig. 1 show respectively the Federal Reserve Board index of production for paper and products and the overall industrial production index. In the latter index the effect of the steel strikes in 1956 and 1959 is clearly evident but not reflected in the paper index, and the 1957–58 corrections in that index are less than in the overall. But it is plain that a forecast of paper production must depend on assumptions about the business cycle—what phase we are in and what is likely to take place in the months ahead.

LOUIS T. STEVENSON, Economist, Tucker, Anthony & R. L. Day, New York, N. Y.

THE BUSINESS CYCLE

From Figs. 1 and 2 it would appear that industrial production, a coincident indicator of the business cycle, has definitely moved lower in the last few months. Inventories have started down and the rate has accelerated in October. This, while it tends to reduce production, is a constructive movement in that when it is completed production can return to a more normal pattern. Expenditures for new plant and equipment have continued moving up, an indication that business confidence in the long run prospects is still high. New orders, the average work week, retail sales, and manufacturing payrolls are all below their peaks. The rise in the consumer price index has slowed and the wholesale (all commodity) index has definitely leveled off. The Federal Reserve rediscount rate has been eased from a high of 4% to a current rate of 3% as an antirecession measure. But personal income and personal consumption expenditures have been maintained.

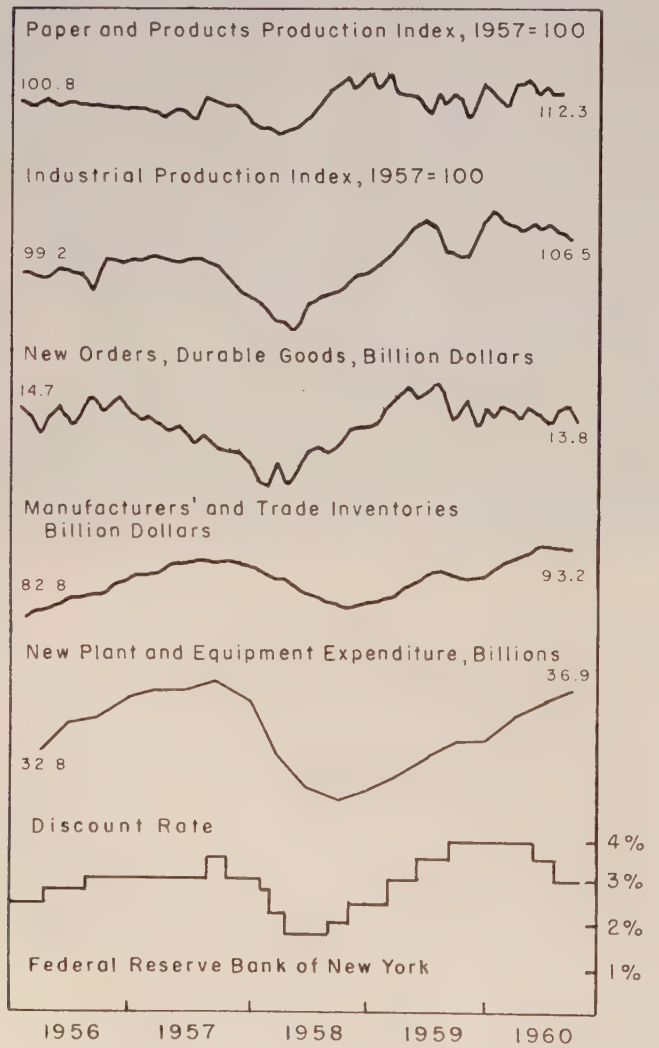

Fig. 1.

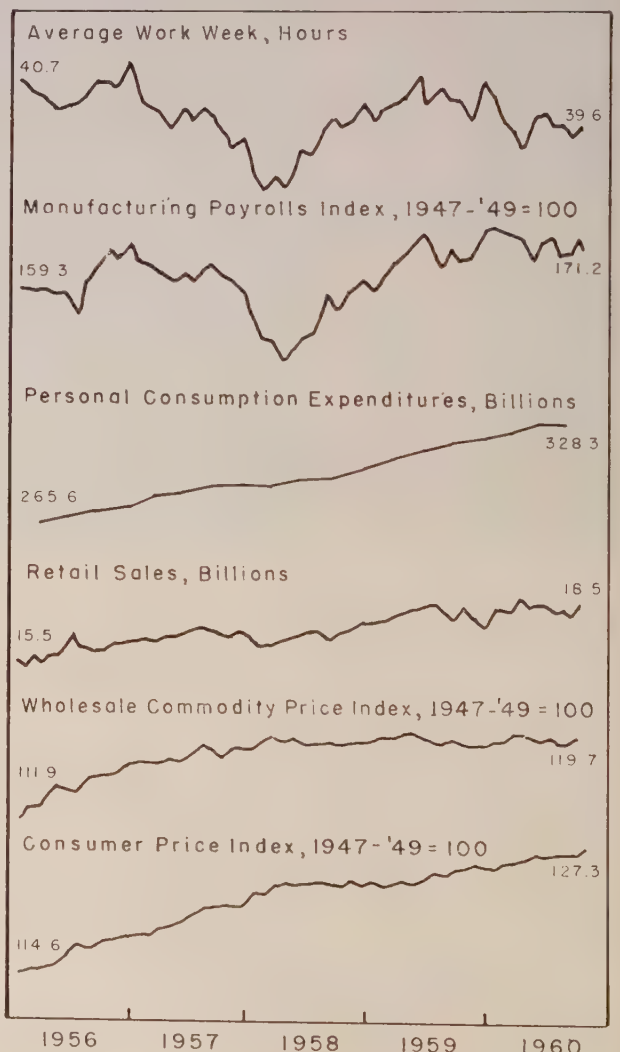

Fig. 2

Selected business indicators

PURE TITANIUM DIOXIDE

RUTILE *and* ANATASE

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This is the pattern of postwar business cycles just after they have started into the recession phase. Present indications are that the recession will be short and that the index of industrial production will start to move up about next May or June. Our forecast of paper production is made on the assumption that the recession will be short and the recovery sharp. Should our judgment prove to be wrong, this forecast should be modified accordingly.

In this forecast three factors will be considered—inventory positions, the effect of the recession and recovery, and long term growth rates.

INVENTORY POSITIONS

Inventory positions for the major groups, paper excluding newsprint and building paper, and paperboard excluding building board, are, according to our latest studies, comfortable to short. This conclusion is drawn from the charts of basic demand and production.

As will be seen in Fig. 3 the production of paper has been fluctuating around the consumption demand line and this past year, 1960, has shown no net accumulation of inventory. In paperboard the chart shows that production has been below the basic demand for consumption much of the time since mid-1959, although the gap has never been very great. Thus we conclude that as of January, 1961, no serious accumulation of inventories in either paper or paperboard will exist. In fact, they are expected to be low.

Newsprint inventories in the hands of publishers in 1960 have followed about the normal seasonal pattern.

Fig. 3. Paper and paperboard production and consumption demand

Newsprint has been in ample supply even though United States consumption has risen, because it is generally sold on long-term contract and there has been no incentive, except a normal precautionary attitude, to accumulate it.

With building paper and board our data are not nearly as complete as in the other grades. But production has been down in this group and one of its principal sources of demand, new housing starts, has been in a declining trend. Consequently, for lack of better information, we assume that inventories have been built up somewhat in these grades.

RECESSION AND RECOVERY

A study of the reaction of the paper industry to the last business cycle shows that production of both paper and paperboard in their broad groups swing up and down, although in varying degrees, with recession and recovery of the business cycle. Their range of movement was not as great as that of the index of industrial production but the timing coincides. Of the individual grades, tissue and sanitary, special food board and folding boxboard were the steadiest, while setup boxboard and other board had the widest decrease from 1957 to 1958, the last year of the recession. Printing and fine and coarse paper production felt the effects of the recession. The most extreme movement was in the containerboard which slid sharply from its high in 1956 and from then remained fairly steady through 1958.

Production in sanitary and tissue grades is little affected by swings in the business cycle, while coarse paper production is influenced by them. Printing, fine, and newsprint are primarily influenced by changes in advertising linage. Changes in business conditions affect special food board and folding boxboard less than containerboard and "other board" while the building grades have proved to be quite erratic but cyclical.

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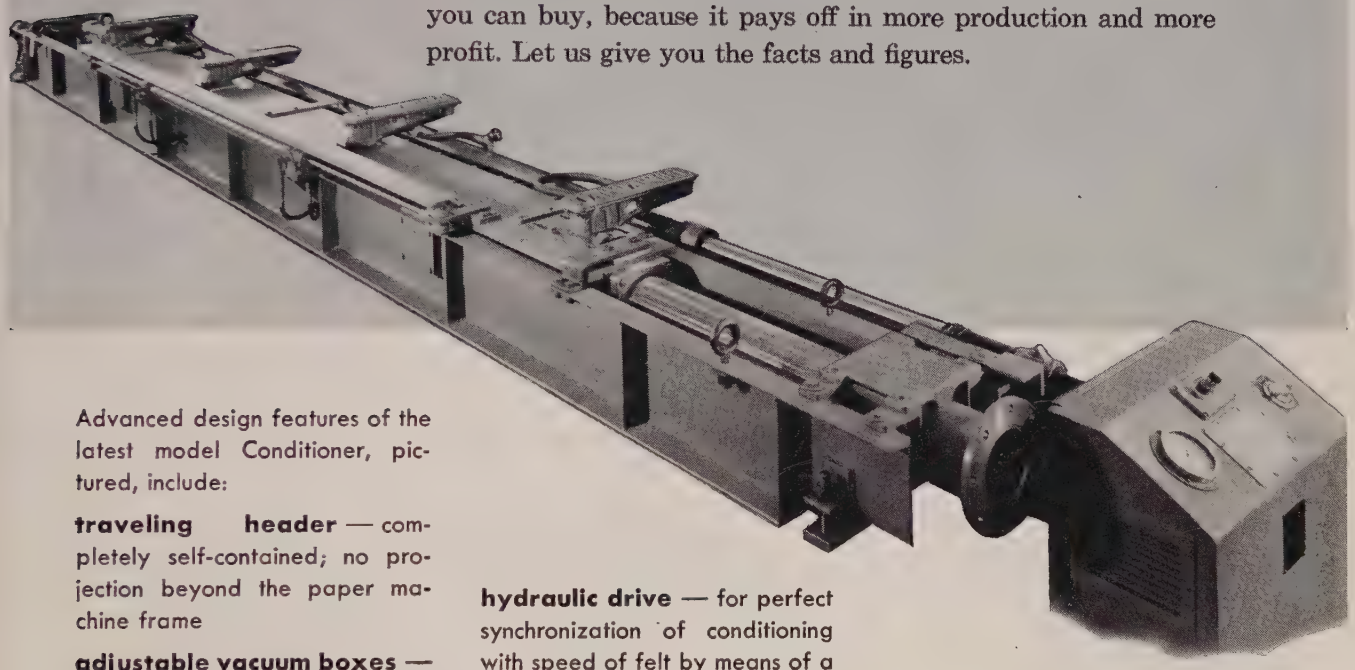
Too *wide*, perhaps. Maybe one, two or three conditioning boxes will take care of the size and speed of press felt *you* happen to be running.

But you *do* need the best, modern, continuous felt conditioning you can buy, because it pays off in more production and more profit. Let us give you the facts and figures.

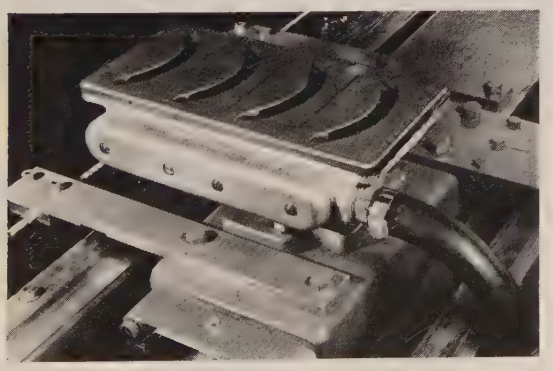


Advanced design features of the latest model Conditioner, pictured, include:

traveling header — completely self-contained; no projection beyond the paper machine frame

adjustable vacuum boxes — both for trim of felt and vertically

hydraulic drive — for perfect synchronization of conditioning with speed of felt by means of a convenient control panel.



Wet Felts Need Continuous Conditioning, Too. Here is a close-up of one of the special vacuum boxes employed on the Vickery Wet Felt Conditioner, which is likewise equipped with traveling header, hydraulic drive and speed control panel.

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GROWTH RATES

In addition to the influence of business cycles, normal growth rates should be considered. The percentages shown below are compound annual rates of growth derived from straight line trends calculated from 1953 to and including 1960. These rates differ somewhat from previous computations which we have published because they are calculated for a different period. The growth rate percentage is dependent upon methods of calculation and the period selected. We believe that the period used here (1953–60) reflects a fundamental change from the inflationary conditions that have generally prevailed in the postwar period.

It cannot be emphasized too strongly, however, that growth rates, for the very reasons suggested above, are no more than indications of current variations among the segments of the industry, and it is with this note of caution that the following table is presented:

Growth Rates for the Period 1953–60

United States paper production by census grade classifications

Sanitary and tissue	6.9%	
Fine paper	4.9	
Printing	3.8	
Coarse	2.4	
Total paper ex-news		3.64%
Newsprint		8.60
Food board	8.4%	
Folding boxboard	3.7	
Containerboard	3.2	
"Other" paperboard	3.2	
Setup boxboard	0.9	
Total paperboard		3.55
Building paper and board		0.9
Total paper and board		3.66

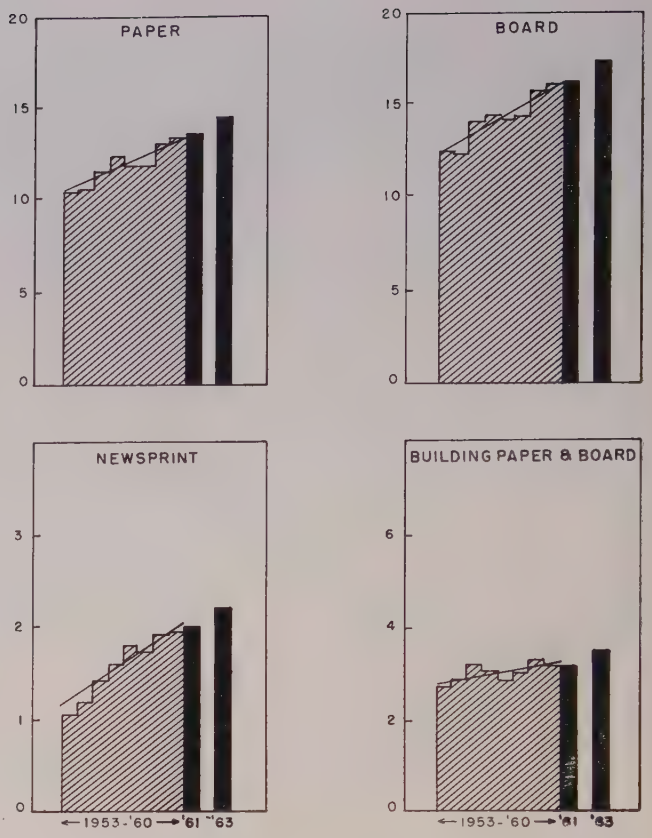

Fig. 4. Production of major grades, 1953–1960, and estimates for 1961 and 1963, million tons

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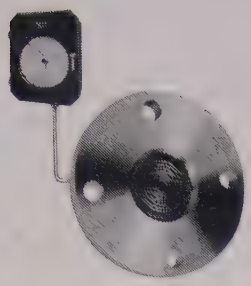
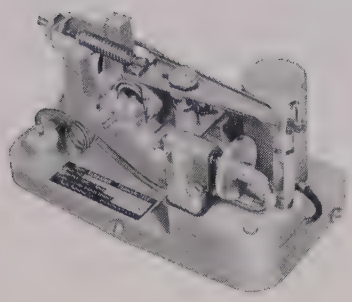
—for more than 20 years the favorite for dependable performance, accuracy and adaptability to changing requirements. For automatic control of almost every phase of paper making.



Liquid Level Transmitter (229R)

—doesn't clog on services involving liquids and liquors with suspended solids which might clog a bubble system. Operates on force-balance principle. Simple, highly responsive.



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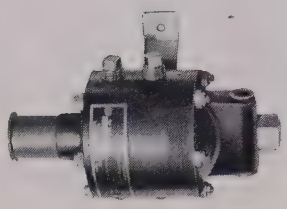

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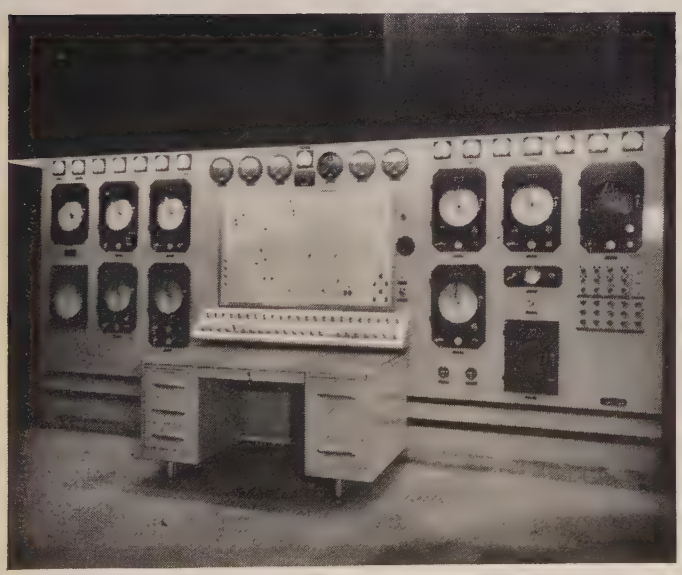
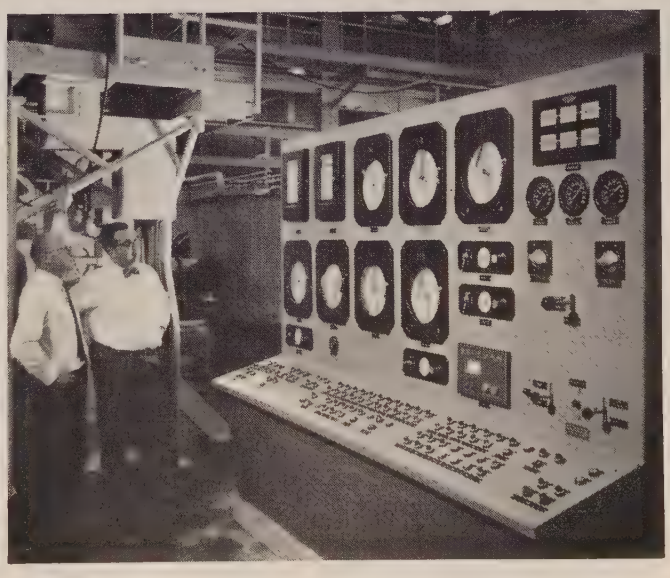


Taylor FULSCOPE Controllers on the control panel for a Continuous Digester System.



Control panel for the wet end of a paper machine, regulating vacuum, pressure, pH, wire speed and level.

Whatever your processing control problems, you can always be sure of helpful advice when you rely on Taylor's years of experience in serving the paper industry. Call your local Taylor Field Engineer, or write Taylor Instrument Companies, Rochester, N. Y., or Toronto, Ontario.

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The high growth rate in U. S. newsprint production needs an explanation. When contrasted with the estimated 2.4% rate of increase of consumption for the same product it naturally raises questions. The answer of course is that the supply of newsprint for the United States comes from three different sources—mills in the United States, mills in Canada, and mills in Scandinavia, and the portion of the United States mills has been growing while the Canadian percentage has been moving in the opposite direction.

Newsprint is the only grade in which import tonnage plays an important role. In the other grades production growth rates approximated those of consumption.

THE FORECAST

The estimates of capacity for the industry show general increases from 1959 to the end of 1961 in all major grades except newsprint, which showed an appreciable decline. Because of this indicated lower capacity and the expected cyclical recession we are not expecting newsprint production in this country to continue its recent growth rate. In fact our forecast for 1961 is put at 2,000,000 tons, substantially the same volume as 1960. Taking into account the mixed effect of the expected recession, the inventory position at the end of 1960 and the growth rates for the other grades, we project the following United States production in 1961:

Grade		*Production (1,000 tons)*
Newsprint	...	2,000
Printing and fine	6,500	
Coarse	4,700	
Sanitary and tissue	2,300	13,500
Containerboard	8,600	
Folding boxboard	3,000	
Setup boxboard	800	
Special foodboard	1,600	
Other	2,100	16,100
Building paper and board		3,200
Total		34,800

It should be noted that we have used the United States Census grade classifications as there are slight differences in classifications between the Census and those of some of the trade associations.

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PROJECTION FOR 1963

Assuming newspaper production at 95% of capacity and projecting all other grades on the basis of calculated trends, 37,500,000 tons overall production may be tentatively given for 1963.

Figure 4 shows, by major classifications, the actual census production from 1953 through 1959, our estimate for 1960, our forecasts for 1961, and the projection for 1963 on the above basis. It should be recognized that the 1963 projection of production is dependent upon the movements of the business cycle and that 1963 capacity data are subject to revisions which may be considerable, because they merely record present plans for the future. More frequently than not these have been changed, both by deferrment and cancellation.

CONCLUSION

The projected 1963 overall production is about 8% over the forecast for 1961, which does not seem unreasonable and would indicate an operating rate on an historic basis of a little under that of 1959 and 1960. On the other hand, should a production slowdown not be of long duration, the forecast for 1961 could be low and this might, in turn, apply in 1963. Long term projections are subject to uncertainties in the business cycle in any case, but it has been our experience that deviations from trend generally vary within fairly narrow limits.

It is our judgment that there should be a pickup in the general economy in the last half of 1961 and to the extent that the segments of the paper industry react to it, 1962 may see a new high level of production in the industry.

December 9, 1960

Twelfth

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Brilliance by Letterpress—with RHOPLEX

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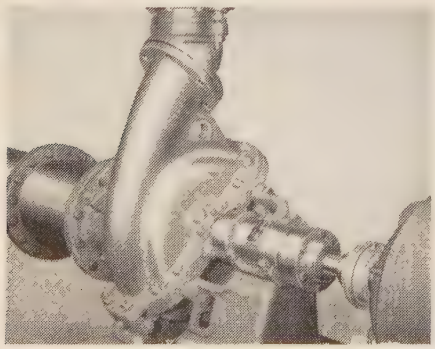
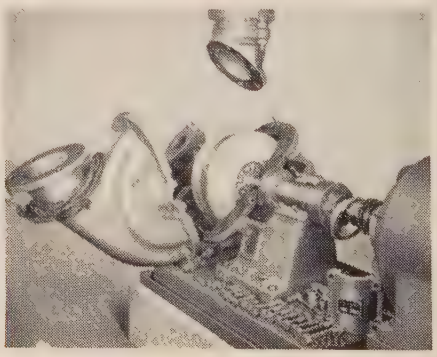


GOULDS PUMPS



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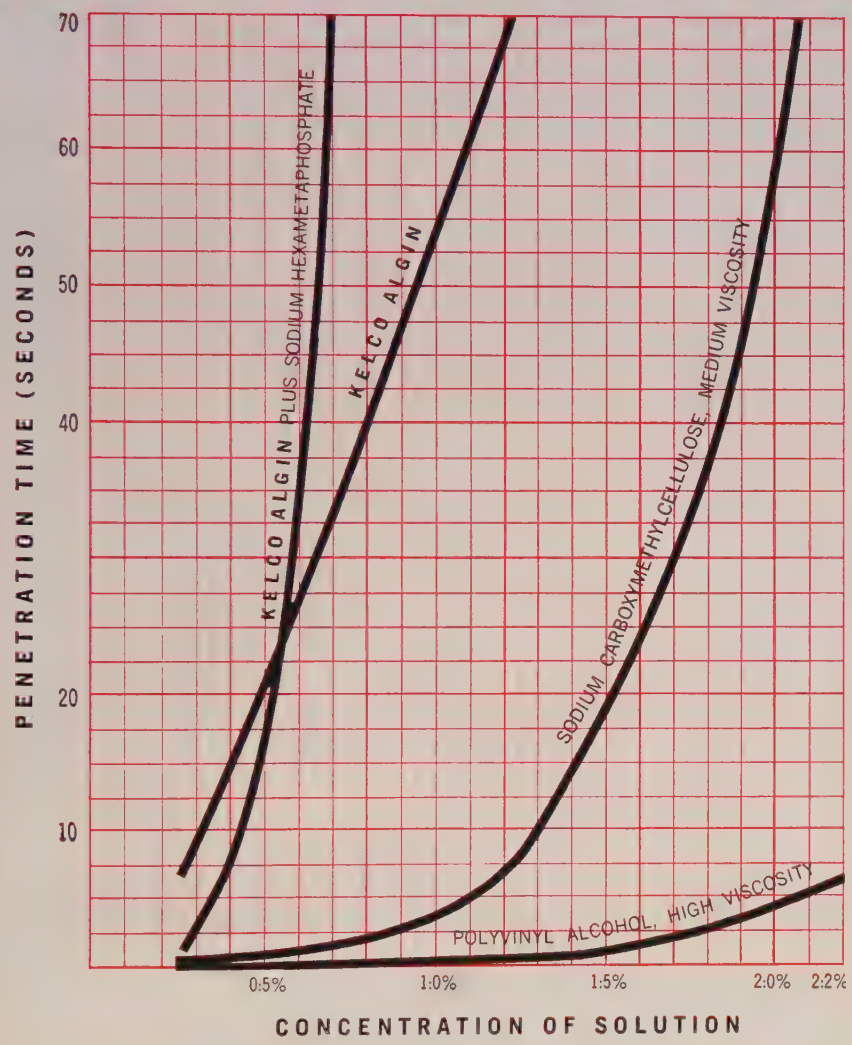
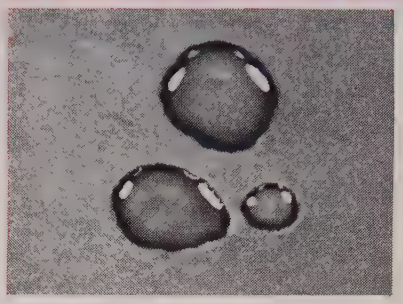
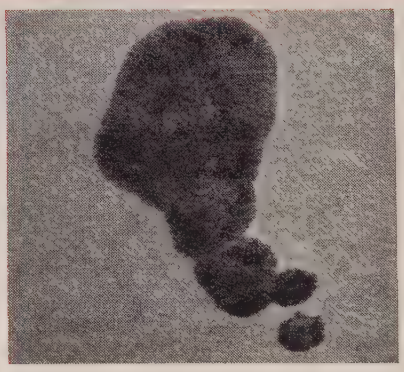




This photograph shows a 1% solution of Kelco Algin twenty minutes after being puddled on blotter. Note how algin controls penetration and retains solution on surface of blotter. This test illustrates the outstanding ability of algin to control penetration. With it you can get the exact degree of hold-out desired for sizings, coatings, adhesives, inks, etc.



Here is photograph of water, without algin, on same piece of blotter taken seconds after water was placed on blotter. Note how water passed immediately into blotter compared to controlled penetration of algin solution.

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This graph and blotter test illustrate and prove that KELCO ALGIN products are among the most efficient materials available for controlling penetration. By using proper proportions of a product such as KELGIN, KELGIN LV, KELGIN XL or KELSIZE, manufacturers of paper products can regulate the amount of penetration of size formulations, clay and wax coatings, printing inks, adhesives, etc. Of course, having your formulation where you want it, without excessive and unnecessary penetration, saves you money.

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Achieving Success in Specialty Papers

STUART U. RICH

I DON'T pretent to qualify as an expert on New England paper companies, or even on the nonintegrated firms, which was the industry segment with which I was chiefly concerned. What I did was to spend about a year and a half visiting a lot of New England mills and listening to some 200 or more executives describe their product line and marketing problems, and what they were doing about them. This work resulted in a thesis, which I turned in at Harvard last May, and which has since been described in a few magazine and newspaper articles. Some of these descriptions, I might add, are a little exaggerated, and I'm not nearly as pessimistic about the future of nonintegrated New England paper companies as some of the headlines seemed to indicate.

I consider it an honor to be here tonight and I hope my remarks may stimulate a few ideas on achieving product line success.

POSITION OF NONINTEGRATED NEW ENGLAND FIRMS

Let's first look briefly at the economic position of the nonintegrated New England paper companies. Although favored by relatively low cost of skilled labor, the New England paper mills, as you well know, must contend with higher raw material, fuel, power, and transportation costs than the firms located in other parts of the country. By producing the higher-priced, quality papers, in which the value added by manufacture is greater, and the profit margin more favorable, these companies have been able to offset to some extent their regional cost disadvantages. Many of these papers are specialty lines requiring a high degree of ingenuity and skill in their manufacture.

The production of these specialty papers is found particularly in New England's nonintegrated mills—the primary manufacturers of paper who lack woodpulp facilities. These firms number about 85, employ a work force of around 20,000 persons, and have a daily productive capacity of close to 6000 tons, which represents about 46% of the region's total paper and paperboard capacity. Let's see how successful these companies have been in recent years.

Table I gives a picture of the sales and profit performance of the nonintegrated New England firms, compared with overall United States averages of both integrated and nonintegrated companies. My sample of 39 companies is based on a representative group of firms in book paper, writing paper, specialty paper, paperboard, tissue, kraft, and shoe board lines. Incomplete 1959 figures showed roughly the same differentials between the performances of the four groups shown in the tables. These companies in my sample, incidentally, account for 70% of total nonintegrated New England production capacity—and somewhat more than that in terms of actual production and sales.

Let's look at the bright side of this picture, however. You can see that there is a small minority of seven mills which could be considered quite successful, and which compare favorably with the industry as a whole. In addition, I found two other firms which, although showing low profits over the entire 12-yr. period, have shown marked improvement during the last 3 or 4 years and could now be included in the "successful" or "well above average," category. It's my purpose tonight to report on the experience of these more profitable firms and to describe what they are doing to achieve their product line success. My remarks will be entirely nontechnical and will focus on general management and marketing problems.

DESCRIPTION OF SPECIALTY PAPERS

One common characteristic of these nine mills with outstanding sales and profit performance was that they all made what are commonly known as "specialty papers." This term "specialty paper" is used a great deal today, with many variations of meaning. One company president, more candid than most, told me that his definition of a "specialty paper" was "someone else's standard grade that we're trying to make." I shall use the term to refer to unusual types or grades of papers which have specific physical characteristics and properties adapting them to a limited number of end uses.

Let me pin down this "specialty paper" term a little now. I think it's useful, in analyzing product lines and product policies of particular companies, to view a firms total output in the form of a spectrum, with the various papers ranged from left to right in order of

Table I. Profit and Sales Performance of Paper and Paperboard Companies

A. Net Profit as a Per Cent of Sales and of Net Worth, Average for the 1947–1958 Period

	Net profit as a per cent of sales	*Net profit as a per cent of net worth*
U. S. Integrated Companies	8.7	12.1
U. S. Nonintegrated Companies	4.6	9.5
N. E. Nonintegrated Companies (39 Cos.)	3.7	6.5
"Successful" N. E. Nonintegrated Cos. (7 Cos.)	5.5	10.0

B. Per Cent Increase in Tonnage and Dollar Sales, 1947–1958

	Tons increase, %	*Dollar increase, %*
United States	46	76
New England	17	..
Nonintegrated N. E. (39 Cos.)	0	43
"Successful" Nonintegrated N. E. (7 Cos.)	10	83

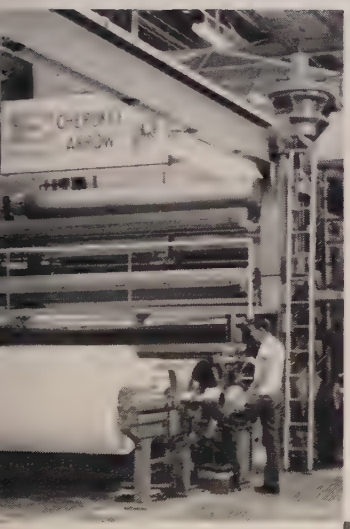
Source: Census of mfrs; appa; data furnished to writer by 19 questionnaire respondents and by 20 companies visited.

STUART U. RICH, Professor, Harvard Business School, Cambridge, Mass.

"Cherokee Arrow" two years later

Ecusta Paper Div. of Olin Mathieson Chemical Corp., Pisgah Forest, N. C.

RICE BARTON



Surpassing even start-up enthusiasm as the biggest, fastest machine for light weight papers, Ecusta's No. 10 has dramatically stepped up both the mill's capacity and its versatility. It is producing up to 55 tons per day of quality-controlled papers in a great variety of weights from 15 to 40 lbs.

The "Cherokee Arrow" is evidence of sound engineering, precision manufacture and coordination with other equipment. When planning your next paper machine expansion or modernization, call us in to prove what *more* Rice Barton can do for you. *Progress is measured in Results not Claims.*

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ng made. It is driven by a
shaft through helical gears
differentials for ultimate in
w control. Three dryer sec-
s have 30 high-pressure paper
4 felt dryers with air-oper-
l felt guides for controlling
sion. Breaker stack with hy-
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and second sections, horizon-
size press between second and
d. Moisture is controlled to
ect for curl before sheet enters
nder stacks and reel. Con-
t tension on winder is main-
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Table II. Product Mix Spectrum for a Company Making Production Grades, Semispecialty Grades, and Specialty Grades

Production grades	*Semispecialty grades*	*Specialty grades*
←——Book Publication and Printing——→		
←——Book Grade Converting——→		
←——Greeting Card Base Stock——→		
	←——Reproduction Papers——→	
	←——Laminating Papers——→	
	←——Miscellaneous Specialty Papers——→	

increasing complexity or uniqueness. On the extreme left are the "regular" or standard production grades, such as offset printing papers. In the middle of the spectrum are the "nontechnical" grades or "semi"-specialties, which, while more complex in manufacture and more limited in use than the production grades, still do not possess the qualities of specialty papers just described. Semispecialties may be former technical grades which have become more standardized in their manufacture and use. Their total industry production volume, for example, may have risen to between 25 and 50 thousand tons, as compared with a total of under 10 thousand tons when they were in the specialty class. Semispecialties may also be special colors, sizes, or surfaces of regular grades, made in relatively small volume. In some cases the "semi-specialty" sold by the small company may really be in the form of a service—that is, the willingness to make special sizes or small lots of regular grades, packaged in a particular manner, and shipped out on short notice to meet certain unusual customer requirements.

While the majority of nonintegrated New England paper mills have product lines which fall all the way across this spectrum, a sizable number, or about 20 firms, have product lines consisting entirely of specialties and semispecialties. A somewhat smaller number, probably not more than half a dozen, make nothing but the highly technical specialty papers. Let's look at a couple of tables that illustrate what I mean by this "product spectrum" idea.

Here (Table II) we see a company with products extending all the way across the spectrum. Some of its reproduction papers, for example, are true specialty grades, while others have become more standardized and are produced in greater volume until they almost reach the production grade category.

This company (Table III) makes a wide variety of semispecialties and specialties, but, because of its size and the nature of its equipment, avoids any of the production grades. Like many specialty mills, this firm must carry on a never-ending search for new technical grades on the right-hand side of the spectrum to replace the less profitable nontechnical ones over here on the left, which may at one time have started out as technical specialties.

Table III. Product Mix Spectrum for a Company Making Semispecialty Grades and Specialty Grades

Nontechnical or semispecialty grades	*Technical specialty grades*
←——Miscellaneous Converting Base Stock——→	
←——Paperboard Closure Stock——→	
←——Tag Papers and Cover Papers——→	
←——Red Wallet Papers——→	
←——Saturating Papers——→	
	←——Gasket Paper and Paperboard——→
	←——Electrical Insulating Papers——→
	←——Filter Papers——→
	←——"Special Products"——→

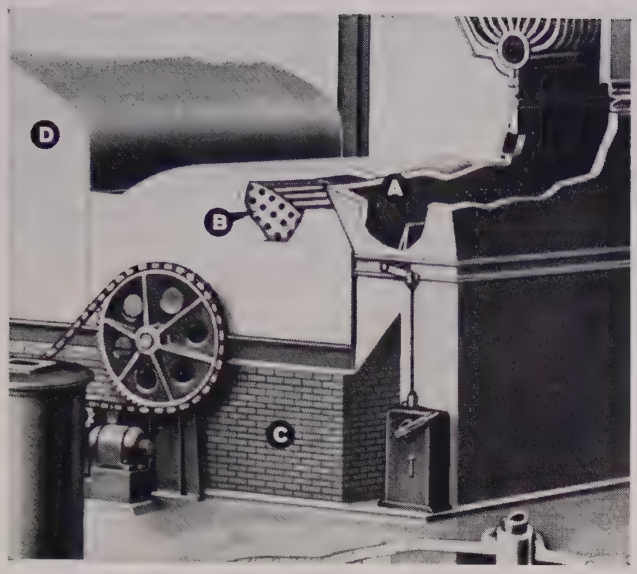
I'd like to move on now to describe what some firms, with product lines similar to those just described, have done to grow and prosper. The rest of my talk will be divided into four main headings: setting objectives, planning the product line, new product development, and total marketing.

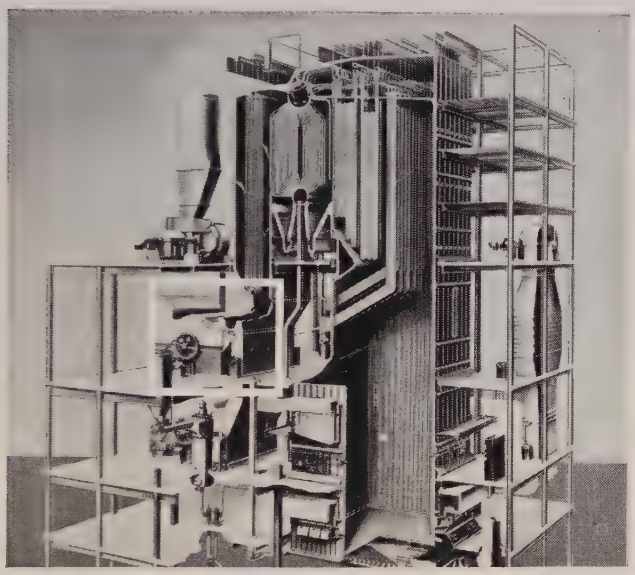
SETTING OBJECTIVES

An underlying characteristic of the successful mills which I studied was a common concern by their managements over just what their company product line objectives were and what role specialty papers played in achieving these objectives. In some cases, the entire product lines consisted of technical specialties, often far removed from paper in its conventional forms. These firms considered themselves not merely as paper producers, but as "manufacturers of industrial webs" or "creators of unique materials." Paper was regarded as a carrying medium for special plastics, chemicals, or resins, for example, and these companies were almost as much in these fields as in the paper industry.

In the majority of companies it was not feasible to become as totally committed to technical specialties as in the cases just noted. A careful appraisal of a firm's strengths and weaknesses sometimes revealed that it was more desirable to concentrate on special grades which had reached a higher volume of industry demand, or had become, in effect, "semispecialties." One company which I visited, for example, produced papers which fell all the way across the production-semispecialty-specialty product line spectrum. Each group had a particular mission to perform. The semispecialties, which were chiefly direct process reproduction papers, were regarded as the main source of profits for the company. The true specialties, which were highly technical grades in the reproduction field, had two main objectives: (1) to provide for a continual flow of potential additions to the semispecialty lines, as fast as some of the latter became production grades and were lost to the integrated mills; and (2) to add greater marketing strength to the semispecialty lines by establishing this company in the minds of customers as "the mill to go to" when looking for a difficult new type of reproduction paper. The standard, or production, grades at this firm, which included offset printing paper, were kept chiefly to help absorb fixed overhead costs. These product line objectives were set by the company president, and it was at joint conferences with all of his top executives that the details of these goals were worked out.

At another company which I visited, however, there seemed to be considerable disagreement as well as a lack of concern as to just what their product line objectives were. This situation had existed for a number of years, and profits had steadily declined until they were only about 1% of sales. At this point, after some prodding by several of the junior executives, top management set up a product objectives committee, headed by one of the sales executives. This committee consisted of eight men, all high up in management ranks, and chosen to represent all the functional departments in the company. Four of the members were older men who had been with the firm 20 or 30 years. The other four had joined the company within the past 10 years.





Cutaway view of a large C-E Chemical Recovery Unit (lower left) equipped with dual Cascade Evaporators. In the evaporation process (upper left), flue gases, after passing through economizer, are divided by damper **(A)** between upper and lower Cascades. Cylindrical tube bundle **(B)** with sealed tube ends rotates slowly in a bath of hot liquor **(C)**. Hot gases passing over the wetted tubes pick up moisture and leave the Cascade at duct **(D)**. The amount of economizer surface contacting the flue gases is varied automatically — adjusting temperature and evaporation rate.

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Automatic controls provide exceptional flexibility of operation. With these controls, furnace stability is easily maintained at a high level, even though the density of liquor entering the evaporator may vary widely. And — because the Cascade Evaporator is mechanically simple and efficient — it performs with a minimum of power consumption and personal attention.

Why settle for less when you specify evaporators? The C-E *Cascade* Evaporator is your most *practical* liquor-concentrating method in the long run. The unit is standard in C-E chemical recovery installations and is recommended for new and existing systems of all makes. Write or call the Paper Mill Division in New York for particulars.

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To start off the work of his committee, the chairman undertook a "Product Objectives Survey" (Table IV) among his fellow committee members. The chairman listed some 15 or 20 possible product objectives, four of which are shown on this table, and polled his fellow committee members on the form shown here, as to what their company's objectives were as they understood them. Somewhat to the surprise and chagrin of top management, there turned out to be practically no agreement among their executives as to just what company product objectives were. This outcome of the survey prompted a thorough investigation as to just where the company was headed and why, and an outside management consultant firm was brought in to follow through on the work begun by the product objectives committee.

It is my impression, I might add, that there are a number of other companies among those which I visited, where a product objectives survey like the one I've described, would uncover similar surprising results. Although common agreement on specific objectives is surely a necessary first step in achieving product line success, it is a step which is often neglected.

PLANNING THE PRODUCT LINE

Let's look at planning the product line. Once product line objectives are set up, continuing success in their implementation requires attention to product line planning on some sort of regular basis. The hardest thing about planning is how to get started. There are several methods which a number of companies used to get underway on their product planning activities.

Table IV. Product Objectives Survey

Individual committee member beliefs as to what our product objectives are	*(Please check appropriate column)* *Agree without qualification*	*Disagree that such an objective exists or have never been impressed that it exists*
1. To manufacture papers classified as "fine" only		
2. To manufacture products falling within the capabilities of our existing equipment only		
3. To be considered the leader in this segment of the fine paper industry		
4. To develop new specialty papers		

One successful firm brought in a new director of marketing, with both sales and technical experience, and set up as one of his major duties the mapping out of a plan to establish a strong technical and market position in resin-impregnating papers. Another company which I visited tied product planning in with a rebuilding operation on one of its paper machines. What started out as a search for new grades to fill up the additional capacity on the rebuilt machine ended up as a complete reappraisal of the company's total product line.

In one company which I visited, product planning played a major part in rejuvenating a tired organization. In this firm, planning of any sort had not only been lacking but had been actively discouraged by top management. When there was a change of management and a new chief executive took over, he introduced product planning as a central function in total company operations.

Product planning in this company took the form of a constant striving for what was termed a "perfect product mix." Let's see how this was done.

First of all, certain overall company objectives were set up (Table V). The first company product line goal shown here—achievement of a higher average selling price—meant simply a continual effort to raise the average price of the total product mix (total dollar sales divided by total tons sold). This goal made sense for two reasons. In the first place the furnish costs of the company's higher-priced woodpulp papers were not significantly greater than those of its cheaper lines. Hence, raw material costs represented a lower percentage of total costs for the quality lines. In the second place, because of its old equipment, there was not a great difference in the machine speeds on the high-priced as compared with the cheaper grades made in

Table V. Determination of "Perfect Product Mix"

A. Product Mix Objectives
- Company Product Line Objectives
  - ——Achievement of a Higher "Average Selling Price"
  - ——Achievement of Capacity Operations
  - ——Achievement of a Predetermined Net Profit Goal
- Additional Departmental Objectives
  - Mfg.—— Mfr. of Grades Best Suited to Each Machine
  - —— Avoidance of Excessive Variety of Colors and Sizes
  - Sales—— Strengthen Declining Market Position in Certain Grades
  - —— Replace "Production Grades" with "Semi-specialties"

NOTE

Eliminate Doctoring in Press Operations! Use MANHATTAN "SELF-SKINNER" Rolls

No doctor, no wipe, no shower, no spray—Manhattan "Self-Skinner" Press Rolls operate at top machine speeds *without* doctors! Only the special paper-repellent composition and cushion-like nip of a Manhattan "Self-Skinner" Roll can assure these advantages on your paper machines:

From web to dryer—wherever "work" rolls are required for critical functions—Manhattan Rubber Covered Rolls are your assurance of top machine performance at lower operating costs.

Let a Manhattan roll specialist show you how to meet top production standards—get "More Use per Dollar"—with Manhattan Press and Suction Press Rolls, Rub-Roc, Sham-Roc, Self-Skinner and Coating Rolls, Sealed-End Couch Rolls and Marblex Table Rolls.

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- Increased Felt Life
- Fewer Breaks, Less Down Time
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this mill. The net result of these two factors was that as the company's average product mix selling price increased, profit margins increased by more than a proportionate amount. Competition was usually less keen on the higher priced lines as well.

The second goal—achievement of capacity operations—was of course desirable because of the high fixed overhead costs typical in paper mills. To achieve the second objective it was sometimes necessary to go after the low-price business. To minimize the conflict between these two goals, this low priced or "marginal" tonnage was sought in products and markets as far removed from the company's regular lines as possible. This meant an aggressive pricing strategy on government bid business and spot tonnage sales in such grades as offset printing papers, which were not normally produced as part of the company's regular product line.

The third objective—achievement of a predetermined net profit goal—represented what the chief executive thought to be an attainable net profit figure for his company, based on what his segment of the industry was doing.

Besides these three company goals, the manufacturing and sales departments each had a number of goals of their own which they hoped to accomplish. I've shown only two of them in each case. For manufacturing: the "manufacture of grades best suited to each machine," and "the avoidance of excessive variety of colors and sizes." The reasons behind these are obvious—to increase the length of production runs and to keep down production costs. For the sales department: to "strengthen a declining market position in certain grades" and to "replace production grades with semispecialties." The company, incidentally, made no technical specialties and had no separate research department.

Let's see now how the company went about planning to achieve the objectives we've shown.

As the first step shown here in Table VI, each department—that is, manufacturing and sales—drew up for the coming year what it felt would constitute an ideal product mix, according to company objectives, plus its own departmental goals. The manufacturing department further broke down its forecasted product mix by machine and by grade for each month of the coming year. Past production records as well as the department's own estimate of future demand trends were used to help in drawing up this product mix goal.

The sales department's product mix recommendations were, in effect, the first draft of its sales budget for the coming year. This budget was based on estimates drawn up by each individual salesman with the help of the sales manager. Each salesman filled out a

Table VI.

B. Sequence

1.		2.		3.		4.		5.		6.		7.
Mfg. Dept's Product Mix	↘	Product Planning Meetings	→	Compromise Product Mix	→	Compromise Mix Revised by controller	→	Further Study by Mfg. and Sales Dept's	→	Product Planning Meetings	→	Perfect Product Mix
Sales Dept's Product Mix	↗											

Table VII. Getting Into Specialty Papers

Goal: Develop a Technical Competence in a Given Area of Fiber Products

Plan of Action on Three Fronts

1. At Suppliers' Plants
   - —— Close Relationships with Laboratory Personnel
   - —— Adaptation of New Fibers and Resins for Papermaking
2. At the Mill
   - —— Experiments in Research Laboratory
   - —— Changes in Paper Machines and Stock Preparation Equipment
   - —— Training of Machine Crews
3. In Customers' Factories
   - —— Search for Product Ideas by Top Management
   - —— Continuing Relationships with Customers

separate sheet for each of his customers. The customers were classified as follows: "established," or acquired prior to the current year; "new," or acquired during the current year; and "prospective," or expected to be acquired during the coming year. On each customer sheet appeared the figures in dollars and tons for each grade of paper which the salesman expected to sell to that customer during each month of the year to come. If the totals of all the salesmen's estimates did not add up to capacity operations for the coming year, then they were gone over again, and, if necessary, a portion of the tonnage deficit was allocated to each salesman. If the totals exceeded plant capacity they were allowed to stand.

In the second stage shown here ("Product Planning Meetings"), a series of meetings was held, under the chairmanship of the chief executive, and the differences between the two sets of recommendations presented by the two departments were ironed out and a compromise goal established ("Compromise Product Mix").

In the fourth step, the controller's department analyzed this compromise product mix recommendation and made such changes in it as appeared necessary to attain the projected profit goal.

In the fifth step, the last version of the product mix, with the controller's changes incorporated in it, was sent back to both manufacturing and sales for further work and study.

Then (under numbers 6 and 7) a second series of meetings was held, again under the chief executive, and a final "perfect product mix" was established through joint discussion by the manufacturing, sales, and controller's departments. This final product mix goal governed the company's total operations. The entire budget for the year was derived from it. This budget, in turn, served as the reference point for the control of costs, and the basis of operating reports to the chief executive. Salesmen's quotas were set up and a salesmen's incentive plan was established, based on the degree of attainment of the budgeted perfect product mix.

NEW PRODUCT DEVELOPMENT

Let's look now at new product development. Here again, just as in setting product objectives and planning the product line, the more successful firms were those which had some unifying concept to help direct the activities of the various company departments toward a common goal. A good statement of such a concept was provided by one company president who said that goal of his mill was to "Develop a technical com-

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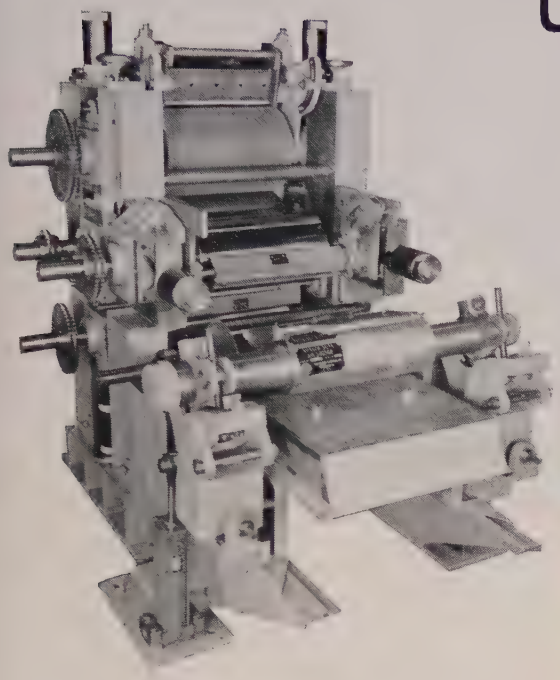

Machine Set-Up	Typical Coating Applied
2 Roll Squeeze Coating	Waxes, Resins, Adhesives
3 Roll Squeeze Coating	Waxes, Resins, Adhesives
Gravure Coating-Offset	Lacquer, Adhesives, Coloring
Gravure Coating-Direct	Lacquer, Adhesives, Coloring
Dip and Squeeze Coating or Saturating	Resins, Waxes, Sizes
Kiss Coating with Metering Bar	Latex, Carbons, Clay
3 or 4 Roll Reverse Coating	Organisols, Plastisols, Latices, Hot Melts
Flexiblade Coating	Clay Coating
Air Doctor Coating	Clay Coating
Knife Coating	Fillers, Binders
Transfer Roll Coating	Clay Coating

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- Riegel Paper Corporation

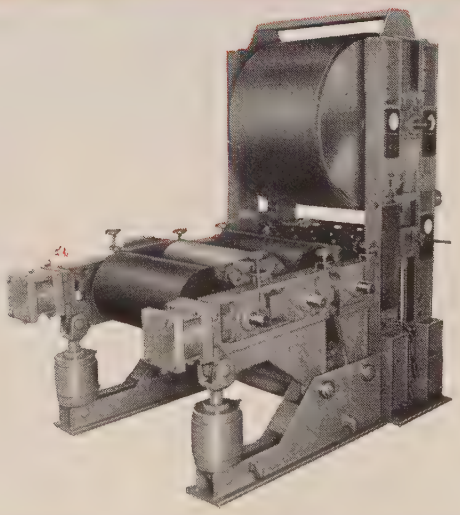

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Table VIII. Product Profile

Criteria	*A. Production grades*	*B. Semispecialty grades*	*C. Specialty grades*
Product			
Suitability for mfr. on present equipment	No additional equipment needed	Only minor additions necessary	Same as B.
Market			
Amount of technical service to customer required	Very little	Some service required but can use regular sales force and technicians	Close customer-mill contact required at all times, involving company executives as well as sales force and technicians
Competition			
Degree of importance in the product mix of competing integrated mills	Not the major grade in the product lines of the integ. mills which make it	Occupies a very minor position in the product mix of competing integ. mills	Not made by any integ. mills

petance in a given area of fiber products." Let's see how this was done at one specialty mill which I visited.

In this particular case (Table VII), the company had, for many years, made rag-content bond and writing papers. When a new president took over, he decided that, in view of increasing competitive pressure from the larger mills, as well as the long-term decline in demand for rag-content papers, the most profitable course of action for his company was to switch completely into technical specialties. His goal was, again, "To develop a technical competence in a given area of fiber products"—in this case, saturating and filter papers.

As outlined in Table VII here, he drew up a plan of action on three fronts: at suppliers plants, at the mill, and in customer's factories. Research and manufacturing personnel called on the major suppliers of fibers, binders, and resins. Close working relationships were set up between the laboratory personnel at the mill and those in several large chemical companies, and experiments were conducted to adapt many new fibers and resins for use in papermaking. Specifications for new fiber or fiber-resin combinations were often worked out jointly between the company and its suppliers.

Back at the mill, experiments with new fibers were carried on in the laboratory and out on the production floor. Many modifications and adjustments had to be made to the paper machines and stock preparation equipment, and machine crews had to be trained in the intricate processing techniques required on the new grades.

To establish a market position in saturating and filter papers, the president knew that strong relationships had to be built up with potential users before much paper could actually be sold. The president himself, with several of his sales and research personnel, traveled extensively throughout the country, visiting many of the top researchers and scientists in large firms which consumed electrical, insulating, saturating, and filter papers. The purpose of these visits was not so much to make sales as yet, but to become thoroughly familiar with the kinds of papers which such industrial users might be buying or might need in the future. This preliminary work in the field resulted in many new products ideas for the company as well as trial orders.

Once definite customer contacts were established, the company salesmen, who were all trained chemists or engineers, made frequent visits to the plants of their firms and kept in constant contact with them. In this way they became thoroughly familiar with how their technical papers were being used, and what types of operating problems their customers were encountering. They also helped customers in writing the specifications for new products and in anticipating the future specialty paper needs of these customers.

Speaking generally now, another characteristic of companies which were successful in their new product development activities was their ability to provide for a continual flow of new product ideas into the company. Fully as important was the ability to screen these ideas and come up with new product proposals with promise of future success. As an aid both to finding the ideas and screening out the promising ones, I'd like to suggest the use of what might be called a "Product Profile."

Table VIII is a product profile for a company whose papers fall all the way across the production-semi-specialty-specialty spectrum. What this profile does is simply to list the criteria which experience has shown that products must have in order to be profitable in a particular company.

I've divided these criteria into three major categories; product, market, and competition. For example, under *competition*, we have "Degree of Importance in the Product Mix of Competing Integrated Mills." Then, in the column under *Production Grades*, we see that the only profitable production grades which this firm could make were those which were not important to competing integrated firms. ("Not the Major Grade in the Product Lines of the Integrated Mills which make it.") Likewise, semispecialty lines should be only those which occupied a very minor position in the product mix of integrated mills; and specialties, not made at all by integrated firms.

For lack of space I've shown only one criterion under each heading, although at a number of mills which I visited I was able to distinguish a dozen or more different product, market, and competition criteria that characterized the successful members of the companies' product lines. For example, here are some other criteria which described the firms, successful products: under *Product:* Degree of technical know-how required, raw materials requirements, estimated length of development period, and so on. Under *Market:* Minimum selling price per hundred-weight, minimum size of typical customer orders, geographical location of customers, and so forth.

This product profile can be used in three ways:

First, as an aid to the salesmen and research personnel in looking for new product ideas;

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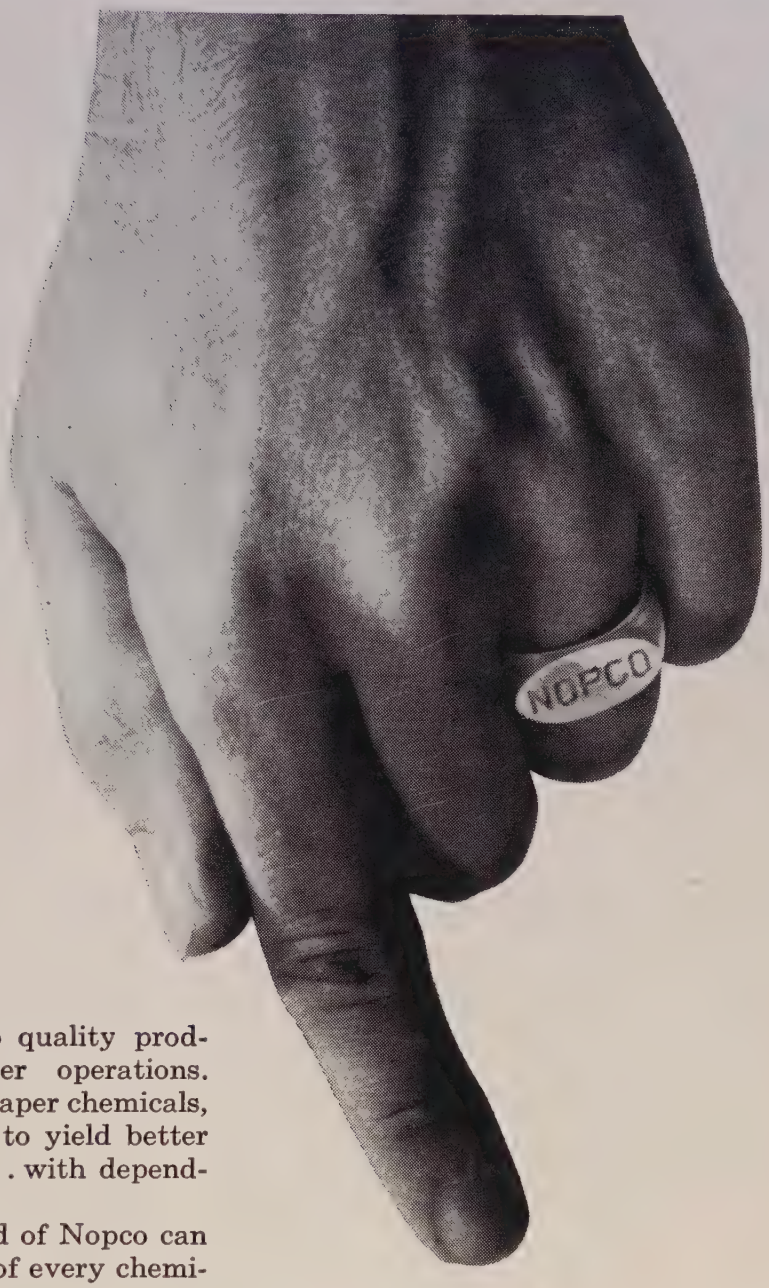

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METALLIC SOAPS	POLYETHYLENE EMULSIONS
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Table IX. Product-Use Profile for Electrical Insulating Papers Made of Special Nonwood Pulp Fibers

Use (specific end-use)	Product (type of paper): Manila rope papers	Extra-thin rag insulating papers	Nonferrous grade asbestos papers	Etc.
Manufacture of conductor wires for motor and generator coils	A	C	C	
Manufacture of special tapes for insulating coils	B	D	D	
Etc.				

A—Our company both makes this product and serves this end use. B—Our company makes this product but does not sell it for this particular end use. C—Our company serves this end use, but does not make this particular product for it. D—Our company neither makes this product nor serves this particular end use.

Second, as a guide, along with the usual profit estimates, for a new products committee or similar group in screening new product proposals; and

Third, as a guide in reappraising a mill's current product line to weed out unprofitable grades.

This profile, of course, can be made as detailed as one wants. Points can be assigned, for example, to the criteria listed and to the degree to which the product in question conforms to these criteria. It goes without saying, of course, that such a profile can be drawn up only after a thorough appraisal of company strengths and weaknesses in all functional areas.

TOTAL MARKETING

Let's look finally at the marketing function in a company selling specialty papers. As a mill moves out of standard lines and into technical specialties, not only does the day-to-day selling job become more complex, but also the sales department finds itself increasingly involved in nonselling activities, such as product planning, new product development, and marketing research. In a number of companies which I visited the salesmen were being supervised and compensated as though they were still selling standard printpapers to paper wholesalers. In one firm, for example, the salesmen were paid on an incentive plan based entirely on sales volume. This gave them little encouragement to carry on an active search for new product ideas, so vital to a specialty mill. In another case, an almost complete lack of guidance or supervision resulted in a lot of wasted effort by the salesmen in bringing in new product ideas quite beyond the capabilities of the mill to develop. The more successful companies were those which recognized the key role which their salesmen played in new product development, and trained, directed, and paid them accordingly.

Let's look at another aspect of selling technical papers. Of all the marketing problems facing the small specialty mills which I visited, one in particular stood out. This was the problem of the high degree of dependence on a few large customers, coupled with the danger of sudden loss of such accounts resulting from technological changes in fast-growing end-user industries. To lessen this danger, one of the more successful mills managed to work out an agreement with one of its large customers whereby the company was allowed to charge a premium price on what it sold to this customer, as long as it carried on a definite program to improve its product to meet the customer's changing technological requirements.

Another way to lessen the danger of excessive dependence on a single large account is to carry on a systematic effort to broaden the customer base. This means some intensive market research by the salesmen out in the field, backed up by some help from research and production people at the mill. As an aid in such market research activities I would like to suggest the use of a type of chart which I shall call a "Product—Use Profile" (Table IX).

Here is a product-use profile similar to one which I drew up for one of the companies which I visited. One segment of this company's product line consisted of electrical insulating papers made of special nonwood pulp fibers. Many of these papers were sold to only a few customers. This chart simply portrays graphically the products which the company makes, or might make, matched against the variety of possible end uses for these products. Down the left-hand side of the chart are listed all the types of uses for the members of the particular product category in question—here, nonwoodpulp electrical insulating papers. Across the top is a list of all the types of papers within this product category, whether made by the company or not. The checkerboard thus formed is then color-coded to show four things:

1. Grades which the company makes for certain specific end uses.
2. Grades made by the company but not sold for certain end uses.
3. End uses served by the company, but by grades other than those made by the company.
4. Grades not made and end uses not served by the company.

For lack of space, this chart shows only a few grades and uses. It could, of course, be made as detailed as one wanted. Another variation on this approach would be to make a "Product-Market Profile" in the same way, merely substituting markets for uses on the left-hand side of the chart. These two profiles, when completed, could tell quickly to what extent customers' needs and the company's product line coincide. In this way, areas of missed opportunity are pinpointed, and a good start is made toward achieving a broader market base for a firm's specialty lines. Furthermore, the very process of drawing up these profiles serves as an excellent training device to acquaint salesmen more thoroughly with their markets, as well as their company's product lines.

I would like to finish this section on marketing by showing a summary job description for a sales vice-president in a specialty mill.

Table X actually represents a typical picture of the responsibilities of sales vice-presidents in several of the

Table X. Job Description for the Sales Vice-President in a Specialty Mill

Responsibility for the Selling Job
—— Building and Maintaining the Sales Organization
— Sales Forecasts, Market Research, Measurement of Effectiveness of Sales Effort
—— Customer Relations, Product Service, and Sales Promotion
Responsibility for Marketing Strategy
—— Recommendations on Product Lines to be Offered and Markets to be Served
Responsibility for New Product Development
—— Encouraging the Flow of New Product Ideas and Screening Product Proposals
—— Expediting the Development of New Product Projects
—— Maintaining Close Liaison Between Mill and Customers

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FILTER

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..Even Filtering Difficult De-Inking Waste Sludge!

In a de-inking process at Combined Locks Paper Company in Wisconsin, wastes from old telephone books are settled out in a clarifier and the underflow sludge filtered on a 10-ft diameter by 10-ft EimcoBelt continuous belt drum filter

Extremely fine fiber and clay particles in these wastes make the sludge exceptionally difficult to filter. Paper company engineers, knowing that frequent and excessive blinding would result on conventional drum filters, chose an EimcoBelt filter for the job on the basis of this filter's proven ability to maintain a clean filter medium handling similar difficult slurries.

With the EimcoBelt filter, operation is continuous. No blinding. No fall-off in filtration rate. The belt filter medium is continuously removed from the drum for cake discharge and cleaning. High pressure wash sprays scour all traces of ink wastes from the metallic filter medium while it is away from the drum.

Filtration rates at Combined Locks average 1700 to 2700 lb dry weight cake per hour. Little or no coagulant addition is required to condition the sludge for filtration. Overall filter performance has exceeded expectations.

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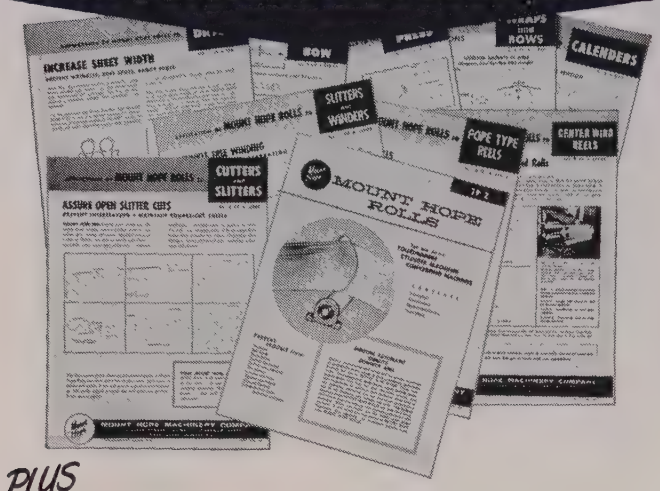

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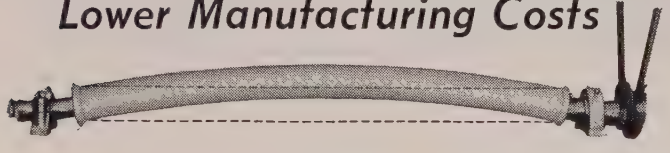

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successful mills which I visited. It illustrates what is meant by the "total marketing" approach required in selling specialty papers. You'll notice that I've listed "Responsibility for the Selling Job" first. This is because the core of the marketing function lies in the day-to-day selling efforts of the salesmen. A sales vice-president's first responsibility lies in the recruiting, selecting, training, and supervising of his sales force. He, or his assistant, assigns sales territories, establishes specific goals for each salesman, and sees that his men are paid according to their attainment of these goals. He's also concerned with sales forecasting, market research, and a number of other activities listed here, all of which have a direct bearing on the effectiveness of his company's sales effort.

The sales vice-president also has a number of broader administrative duties. For example, he makes recommendations to the president on company marketing strategy—that is, what products to sell and to whom. As we have already seen, the sales department also plays a major role in new product development, starting with an active search for new product ideas, on through to the maintenance of close relationships with customers after the new grade has become a regular member of the company's product line.

In conclusion, I'd like to say that there was one feature that seemed to stand out most in the successful mills which I visited, and which explained the reasons why these companies acted as they did. This feature was the *possession of three primary attitudes* or traits by the chief executive. These are: a willingness to undertake risk, a desire for innovation, and the ability to plan ahead. Where these attitudes were present, economic and competitive difficulties were overcome, and the company grew and prospered.

Presented at the meeting of the Bay District of the New England Section of TAPPI, held in Framingham, Mass., Nov. 14, 1960.

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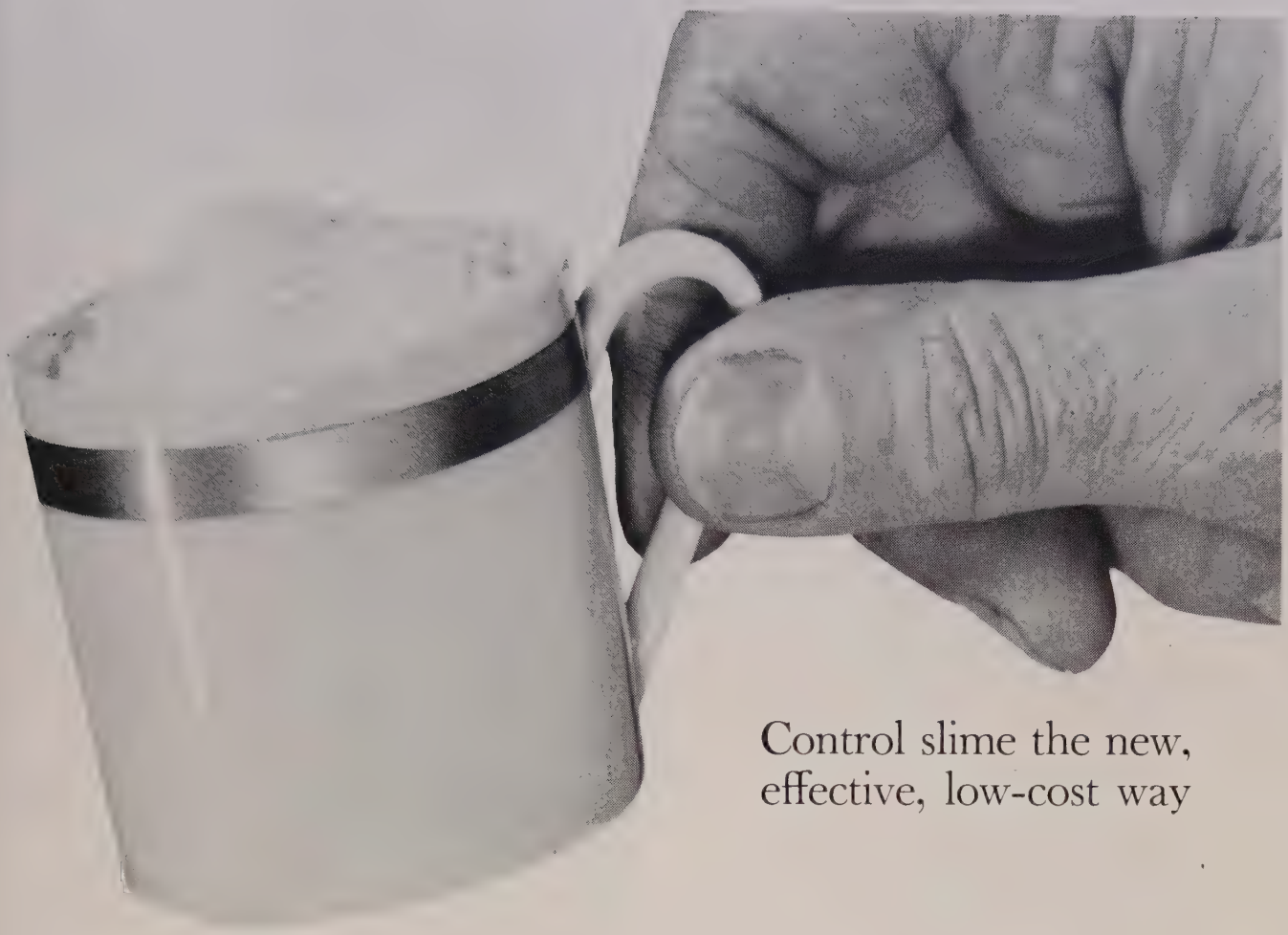

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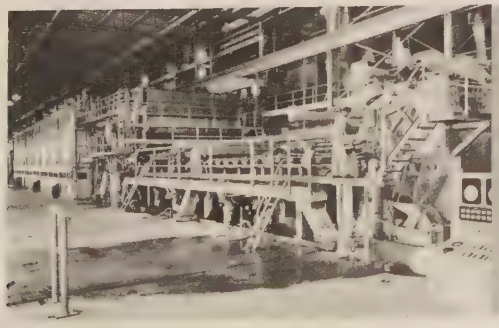


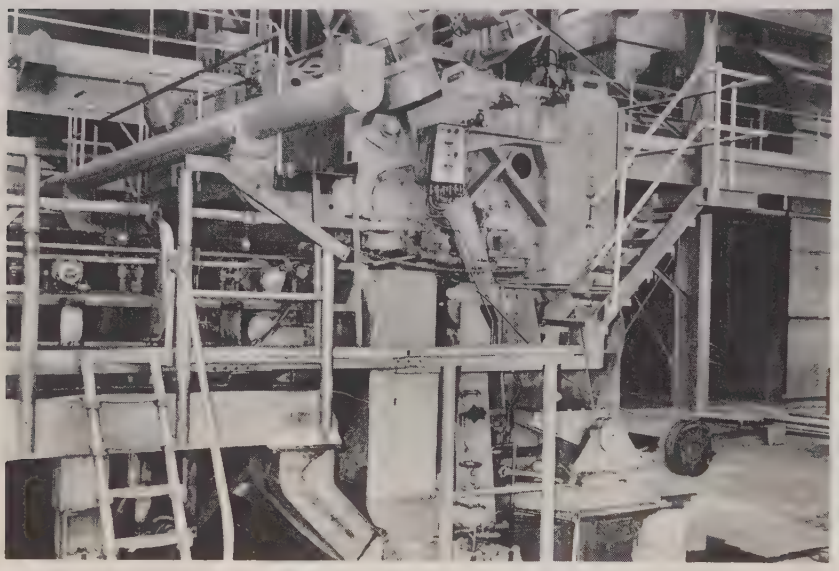
Southern Kraft Division, Pine Bluff, Arkansas

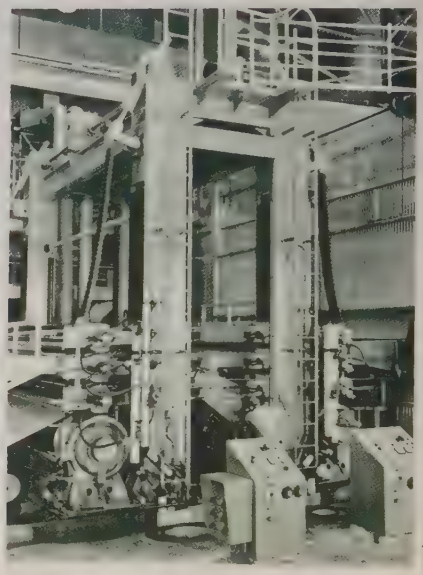
Pine Bluff's new 209″ Fourdrinier paper machine is equipped to manufacture newsprint and directory paper to meet the expanding demand for these grades in the South. This is the third Beloit machine in operation at Pine Bluff. The first two machines began operation in mid-1958, producing newsprint and bleached kraft paperboard. For further views of the new machine, please turn the page.

...some views of the new 209″ Beloit Fourdrinier paper machine at Pine Bluff

(a) Beloit patented air-cushioned controlled-flow inlet showing a portion of the cantilever-type Fourdrinier. Design speed of this machine is 2000 fpm. **(b)** Twin open side Beloit calender stacks. The stacks are equipped with patented nip relief arrangement. **(c)** International Paper Company's Pine Bluff Mill. The new machine room is situated at left foreground. **(d)** Beloit Eastern Corporation 6000 fpm Model L Winder and heavy-duty unwind stand. **(e)** Twinver press arrangement; other press features include automatic suction pick-up and third suction press.

a





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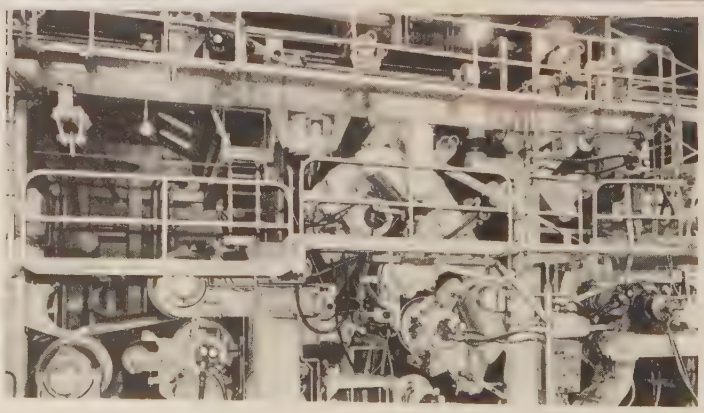

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Industrial Water Conservation and Re-use

RICHARD D. HOAK

RECENT years have seen publication of many popular and technical articles on the inadequacy of national water resources for future needs. Some of the popularizations approached hysteria in their implications that this country would soon lack sufficient water for essential purposes. Even projections by competent analysts have suggested that widespread shortages of water may occur within 40 years. These publications have caused surprise and a certain alarm, because, in the humid east, water has usually been considered to be as abundant as air. There have, of course, been droughts of varying severity, but these have been regarded as transitory phenomena that reflected no long-range threat to water supplies.

A rational appraisal of the current status of water supply in the United States can be made from published data, and a projection of the water supply–demand relationship can be based upon consideration of economic and technological factors. The U. S. Bureau of the Census has made the first comprehensive survey of industrial water use, and the Senate Select Committee on National Water Resources has been collecting information on every aspect of water supply and use.

The annual rainfall on continental United States averages 30 in., of which 21.4 in. quickly returns to the atmosphere through evapotranspiration, and 8.6 in. runs off to streams as percolates into the ground-water table (*1*). This corresponds to an average daily supply of about 1.22 trillion gallons of water potentially available for municipal, rural, irrigational, and industrial uses. Hydrologists have indicated that it may ultimately be economically feasible to develop some 635 billion gallons per day (b.g.d.) from rainfall runoff, and it can be assumed that enough ground water will be available on a sustained-yield basis to bring the total for all water uses to about 650 b.g.d. (*2*).

The most recent data on current uses of water, excluding hydropower, are listed in Table I.

Hydropower generation in 1950 used about 1100 b.g.d. but this is not included in the total because the water is unchanged except for its loss of potential energy.

Table I suggests that the United States needs 231 b.g.d. for all purposes. But this is really the gross requirement; the net need is rather different. Surface water is used many times over as it flows from its sources to the ocean and the true need is the volume that is actually consumed by evaporation, incorporation in products, or otherwise temporarily eliminated from the hydrologic cycle. There is a tendency among those who predict an impending national shortage of water to imply that use means consumption—that most of the water withdrawn by industries and municipalities is not really re-used. It can be conservatively assumed that there is complete consumption in rural use, 10% consumption of municipal and industrial withdrawals, 1% for steam power generation, and 60% for irrigation. Thus the supply of new water to support all these uses would be about 72 b.g.d. (4 + 1.7 + 3.4 + 61.8 + 0.7). In view of the large average excess over actual needs, it may be wondered why there is any necessity for conserving water. The answer lies, of course, in the use of average values to relate water supply to water demand.

Table I. Current Water Use

	B.g.d.	*Year*	*Reference*
Rural	4	1950	*3*
Municipal	17	1954	*4*
Industrial	34	1954	*5*
Irrigation	103	1954	*6*
Steam—electric power	73	1959	*7*
U. S. total	231		

RICHARD D. HOAK, Mellon Institute, Pittsburgh 13, Pa.

Continental United States enjoys a generous supply of water on a basis of the national average, but many areas always have too much or too little, depending upon the season, and sporadic droughts unbalance regional water economies. Rainfall provides the national water supply, but precipitation varies widely in both place and time. For example, in certain valleys of southern California about 88% of the rainfall occurs in about 1% of the time, and on the Olympic Peninsula of Washington the average annual rainfall changes from 150 to 10 in. in a distance of 45 miles (*9*). Many similar examples could be cited to illustrate the importance of variable rainfall in coping with the problem of maintaining dependable water supplies.

The tendency for manufacturing industry to concentrate in a few regions is illustrated by the so-called "manufacturing belt" which stretches eastward from the Mississippi, north of the Ohio and Potomac Rivers. In the 40 years since this belt was first identified there have been large increases in manufacturing in other regions, notably in the Midsouth and in the Western Gulf States and Pacific States. But there have also been great increases within the belt, which continues to be the area of heaviest concentration (*10*). Industrial development generally occurs in or near metropolitan centers to be close to a labor pool, municipal services, and markets. These concentrations aggravate local water-supply problems where industrial requirements may exceed available supplies from time to time. Water conservation will necessarily be practiced more assiduously in such areas than where fresh water is abundant, because the need for enough water is the important consideration, not the economics of conservation.

Withdrawals of water by industry groups, including sources, are listed in Table II (*11*). This tabulation covers only industries using 20 million gallons or more per year; the total for all those withdrawing less was estimated to be 320 b.g. in 1954. Not included is 1622 b.g. of brackish water used in 1954. The second column in the table lists the total volume withdrawn for all purposes; the third column shows the amount that would have been needed had there been no re-use.

Several interesting facts about industrial water use are disclosed by Table II. The first five industries listed withdraw about 85% of the total. These large users also employ water efficiently. Each gallon withdrawn is used 1.9 times before discharge; for the pulp and paper industry the figure is 2.6. All other industries use their intake an average of 1.3 times. About 14% of the industrial intake comes from municipal supplies. Dependence on such sources might disrupt operations during droughts, because industrial demands are normally the first to be curtailed.

Temporary water shortages are relatively commonplace. They result from five broad causes: localized population growth; increased seasonal use; increased industrial use; supply failure; and lack of foresight in planning for future needs. A survey of the 1953 drought by the American Water Works Association (*12*) disclosed that 1072 public water

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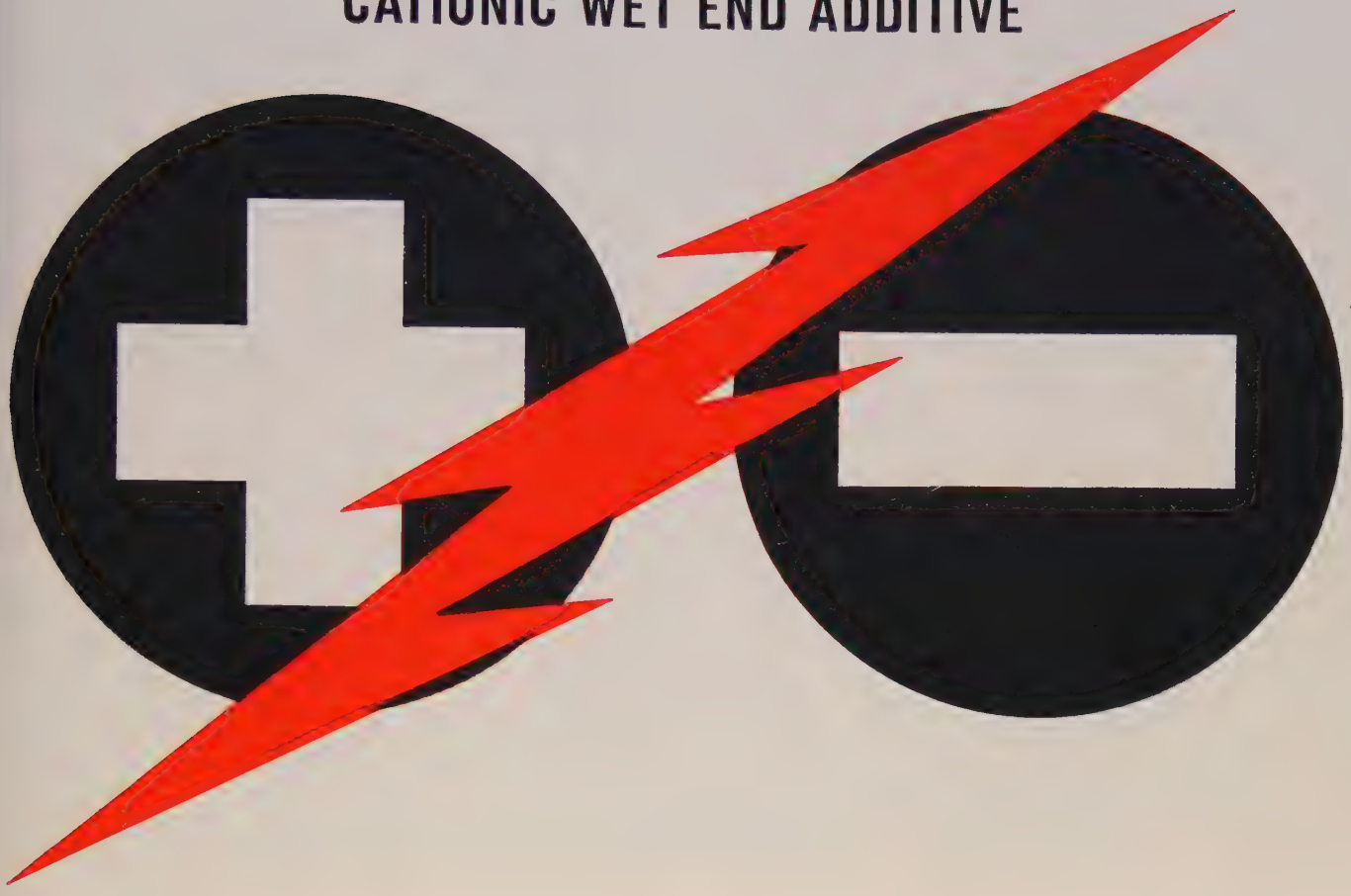

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Table II. Industrial Water Withdrawals, 1954, Billions of Gallons (*8*)

Industry	*Total intake*	*Withdrawal if no re-use*	*Sources of fresh water*			
			Total	*Public*	*Co. surface*	*Co. well*
Primary metals	3,651	4,654	3,420	271	3,044	105
Chemicals	2,857	5,004	2,297	212	1,451	634
Pulp, paper	1,613	4,129	1,472	211	998	263
Petroleum and coal	1,519	4,515	908	117	689	102
Food	677	1,258	530	200	120	210
Textile mill products	287	307	270	47	108	115
Stone, clay, and glass	282	563	246	25	199	22
Transportation equipment	259	353	244	162	57	25
Fabricated metal	220	275	195	177	5	13
Lumber and wood	166	155	107	10	81	16
Machinery, except electrical	143	183	117	58	37	22
Electrical machinery	126	142	107	71	29	7
Rubber	115	170	108	43	48	17
Miscellaneous manufactures	74	94	54	25	14	15
Printing and publishing	36	19	13	12	1	*
Leather and leather goods	25	22	19	12	4	3
Instruments	22	54	19	5	10	4
Furniture and fixtures	16	8	7	3	4	*
Apparel	16	*	*	*	*	*
Tobacco manufactures	3	11	2	2	*	*
U. S. total	12,077	21,906	10,135	1,663	6,899	1,573

* Less than 500,000 gal.

supplies serving 24 million persons in 45 states were forced to restrict water use by all or part of their customers. Of these waterworks, 27% needed additional water supplies and 68% required expanded treatment and distribution facilities. The report points out that adequacy is more easily reviewed than predicted, but industries dependent on municipal supplies should cooperate with local agencies by informing them about anticipated future demands for water that might call for improvement of distribution facilities or development of additional supplies.

The wasteful use of water by the people of this country clearly indicates that it is regarded as a substance of low value. Water is not wasted in certain western areas because, as an old proverb reminds, "One knows the value of water when the well runs dry." But wasteful use of water elsewhere is a direct result of its abundance and low cost. Nevertheless, there are conflicts over the several uses of water and it has been proposed that these disagreements might be resolved by placing a dollar value on water uses. Renshaw (*13*) computed the values given in Table III.

The figures in Table III are gross values which include the various costs incident to the preparation and delivery of water. These values can be thought of as "the maximum amount people would be willing to pay for the use of water in any amount or direction rather than forgo the amount or use entirely." These figures are intended only to illustrate the possibilities for making comparisons of water values; arbitrary decisions to include particular cost elements would affect relative values. The table shows that among all uses, domestic use is the most valuable, and that it is followed closely by industrial use. There is a large gap between the value of water for these uses and its value for irrigation, power, and waste disposal.

In general, as the cost of products increases the demand for them decreases, but this cost–demand relationship is not clearly defined for municipal water supplies. This vital necessity is so relatively cheap that its use probably would not be significantly decreased if its cost were trebled. Where there have been sharp increases in the price of municipal water, demand has been depressed for a short time but has tended to regain its former level (*14*). Industries using domestic supplies are more sensitive about the price of water because it represents a part of the cost of manufactured goods. This is especially true where municipalities impose sewage disposal charges based upon the volume and strength of waste water. Introduction of water-conservation devices have often shown a profit through reduction of water bills.

Table III. Value of an Acre-foot of Water

Use	*Mean*	*Maximum*
Domestic	$100.19	$235.66
Industrial	40.73	163.35
Irrigation	1.67	27.04
Hydropower	0.71	5.90
Waste disposal	0.63	2.56
Inland navigation	0.05	1.17
Commercial fisheries	0.025	1.06

The cost of industrial water varies widely. The larger users generally develop their own supplies to provide water at a cost of 5 to 10 cents per 1000 gal. Establishments with smaller requirements usually purchase from public utilities at costs ranging from 12 to 28 cents per 1000 gal., depending upon the volume used (*15*).

Industrial re-use of its own waste water and use of treated domestic sewage for cooling are being practiced increasingly where fresh water is costly or not available in sufficient quantity. In some areas it has been found cheaper to use municipal waste water than other sources. Some examples of cost of such water are given in Table IV (*16*).

PROJECTIONS OF INDUSTRIAL WATER REQUIREMENTS

Growth of population and industrial activity imply a progressive increase in the use of water, and there have been a number of estimates of future water demands. The most recent projections have been made for the Senate Select Committee.

Per capita use of municipal water, which was 147 gal. per day in 1954, is not expected to change very much over the next 40 years. Total use of such water may rise from 17 b.g.d. in 1954 to 29 in 1980 and 43 in 2000, based upon a middle rate of population growth (*17*), representing increases of 170 and 250%, respectively, over 1954.

But the projections for industrial use of water are much greater. Resources for the Future (R.F.F.) and the Business and Defense Administration (B.D.S.A.) of the Department of Commerce have each estimated future industrial needs for water. Both organizations used as a basis the six industries that accounted for 63.5% of the industrial water intake in

Table IV. Cost of Re-used Water

Location	*Used in*	*Vol./yr., m.g.*[a]	*Cost, ¢/1000 gal.*
Grand Canyon, Ariz.	Power plant	65	37
Los Angeles, Calif.	Sewage plant	3,900	1.2
Baltimore, Md.	Steel plant	40,000	3.5
Amarillo, Tex.	Oil refinery	520	4.3
Big Spring, Tex.	Oil refinery	720	4.9

[a] m.g. = million gallons.

Photos courtesy Donnacona Paper Co. Ltd., Donnacona, Que.

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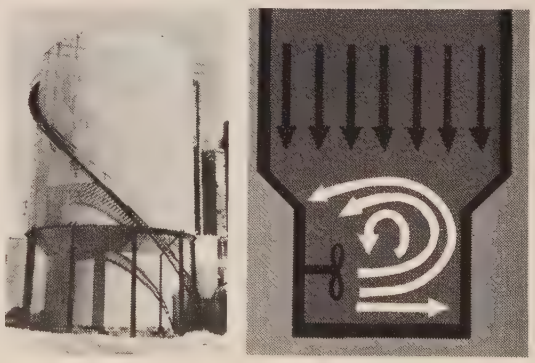

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Table V. Comparison of Two Projections of Industrial Water Needs, Billion Gallons Daily

Industry	1954	1980		2000	
		R.F.F.*	B.D.S.A.	R.F.F.*	B.D.S.A.
Iron and steel	7.74	19.52	18.73	35.14	22.49
Chemical	6.52	29.59	22.03	81.35	52.88
Pulp and paper	4.40	18.88	14.39	44.31	28.65
Food	1.62	2.74	2.33	4.11	2.76
Aluminum	0.72	1.66	1.66	3.12	3.12
Copper	0.12	0.31	0.21	0.68	0.27
Total	21.12	72.70	59.35	168.71	110.17

* Estimates based upon a medium rate of economic growth.

1954. This year was chosen for reference because it is the most recent one for which complete data are available. These projections are compared in Table V (*18*).

The data in Table V illustrate the hazard of estimating future water demands. Both organizations used the same figures for 1954, but their projections were based upon different measures of economic growth. R.F.F. computed indexes for three growth rates: low, medium, and high; B.D.S.A. developed indexes for only one growth rate. The B.D.S.A. indexes for 1980 and 2000 are of about the same order of magnitude as the R.F.F. indexes that correspond to a low rate of economic growth. If the R.F.F. prediction for the middle growth rate were assumed to be correct, and if the volume for the six industries were extrapolated proportionately to all industry, the total industrial withdrawal of fresh water in 40 years would be 275 b.g.d. Adding the projections for municipal, rural, and irrigational water (as estimated for the Senate Select Committee (*17*, *19*) the total needed for all uses except hydropower would amount to 490 b.g.d. This would be perilously close to the 650 b.g.d. predicted by the hydrologists to be the maximum fresh water ultimately available. Prognostications of this kind appear to have led some people to the conclusion that the national water supply will be approaching inadequacy by the year 2000. Adjusting this prediction for water actually consumed, as was done for the data of Table I, and including a loss from steam–electric power generation on the assumption that this industry will continue to double its capacity every decade, the net volume of new water that will be needed 40 years from now becomes 144 b.g.d. The U. S. Department of Agriculture has predicted that increased efficiency in the use of irrigation water will reduce by about 20% the volume required. Thus the net daily loss of water may be decreased to 117 b.g.d. or 18% of the estimated daily yield of water.

Gilbert White, a notable student of water resources, recently reviewed industrial use of water (*20*). His comparison of various predictions of industrial water withdrawals is given in Table VI.

The estimates given in Table VI for 1954 substantially exceed the total withdrawals reported in the census (33.1 b.g.d.). White concludes that, "If projection and fact continue to differ by the same proportions over a few years, the earlier estimates for 1975 and 1980 will be far out of line." Partial causes for the discrepancies are the relative comprehensiveness of the uses included in the estimates, and the wide variability in water use per unit of product. But there is no full explanation for the differences in the several estimates of industrial use.

Table VI. Estimates of Industrial Water Withdrawal, 1950–1975

In average billion gallons daily

Source	1950	1954	1955	1975
President's Materials Policy Commission	45.0	52.2	54.0	90.0
U. S. Department of Commerce	46.0	57.2	60.0	115.4
Woodward (including steam–electric power)	69.1	93.1	99.1	350.0
MacKichan	...	...	38.7	....
U. S. Census of Manufactures	...	33.1	...	....

It seems evident from the foregoing that the United States as a whole possesses an ample supply of water for all uses and that this will be true far into the future. But figures that reveal national adequacy obscure localized water supply problems. Many areas in western states suffer from a perennial shortage of water, and the droughts that afflict the east cause serious temporary interferences with industrial activity. Water resources must therefore be viewed in terms of local supply–demand relationships.

Except in acute emergencies, no adjuration that conservation is a civic duty is likely to save much water. Industrial conservation of water is practically always governed by economics, and there are many published accounts of large net savings in the cost of water, even in areas where the normal supply is plentiful. Whether the supply is privately developed or purchased from a water utility, the value of the water saved must exceed the cost of the conservation measures adopted. The potentiality for water conservation can be illustrated by comparing data for two highly industrialized nations. Daily per capita withdrawal of industrial water in the United Kingdom is 46 gal, in the United States it is 204 (*21*). But wasteful use of water by industry is gradually being recognized as a significant economic loss.

GENERAL CONSERVATION MEASURES

Industrial plants built when supplies of fresh water were seemingly inexhaustible were designed to operate efficiently with a large volume of once-through water. Revision of existing equipment for re-use of water might be very costly. Nevertheless, there are a number of ways to conserve water in old plants.

An obvious way to reduce water requirements is to prevent wastage, but it is remarkable that such a simple expedient is so little practiced. The volume of water used in various operations is often many times the amount actually needed. Workmen will open a valve full when a half or quarter-turn would be sufficient. Also, there is rarely an incentive to close a valve when the water is no longer needed: workmen do not appear to realize that it costs money to pump water. One company saved $100,000 annually by reducing wasteful water usage 40% through installation of devices that cost $150,000 (*22*).

Waste can be reduced by installing automatic valves that close when a piece of equipment is not operating. Hoses and drinking fountains should have spring valves that close when released; one company was wasting 30 million gallons a year by permitting 117 drinking fountains to run continuously. Sanitary fixtures and faucets should be regularly checked for leaks. A leakage survey of piping will often disclose unsuspected waste; underground surveys can be made without digging, or breaking concrete floors. Meters installed on lines to each department would provide a check on consumption; supervisors will enforce conservation when they realize that water costs are being charged to their departments. Thermostatic controls should be used to regulate the flow of cooling water. Heat exchange equipment should be kept clean; regular descaling to improve heat transfer may save 25% in cooling water. Up to 95% of once-through cooling water can be saved by recycling the water through cooling towers, spray ponds, evaporative condensers, and the like.

WATER CONSERVATION IN THE PULP AND PAPER INDUSTRY

The U. S. Census of Manufactures reveals that the pulp and paper industry is the third largest user of water among the 20 industrial groups covered. Excluding steam–electric power, the industry took 13.4% of the total industrial withdrawal in 1954. Table II shows that the industry has a good record for conserving water. The projected growth in manufacture of pulp and paper products, however, suggests that even more conservation will be necessary in the future.

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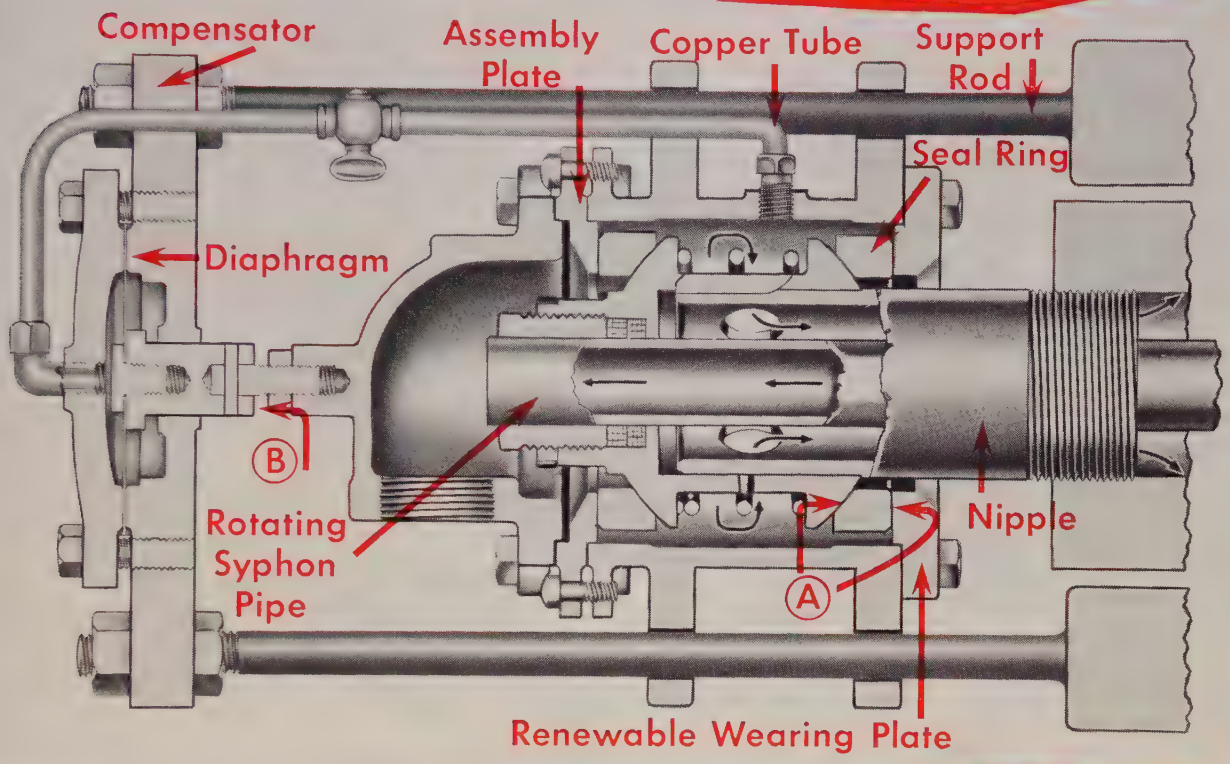

This one wasn't easy—a rotary *pressure* joint for *vacuum* service. It is used principally on the wet end section of some paper machines.

A modification of the Johnson Compensator does the trick. It exerts force by means of pressure against one side of a diaphragm, or vacuum against the other side. Mounted as shown, with vacuum in the joint transmitted to the Compensator, it produces a force at B which results in just enough pressure at A to maintain a tight seal. It works equally well under high or low vacuum conditions—maintains a constant sealing pressure regardless of any fluctuations.

This Type L-N rotary joint, designed to accommodate a rotating syphon pipe, functions just as it would in normal pressure service. The seal between rotating assembly and stationary housing is accomplished without any packing. No lubrication or adjustment is needed. The support rods carry all the weight of body and connections—permit the rotating assembly to "float" freely inside. Special assembly plate provides easy access to syphon pipe without disassembling the joint.

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Table VII. Production Indexes for Pulp and Paper Industry

Total pulp, paper, and board	*1959*	*1980*	*2000*	*Increase, 2000 over 1959, %*
R.F.F.	169	482	1190	604
B.D.S.A.	169	370	773	357

Ackerman and Löf point out that manufacture of paper and paperboard products expanded twelve-fold from 1899 to 1954 and pulp production increased fifteen-fold in the same period (*23*). R.F.F. and B.D.S.A. have computed production indexes for 1980 and 2000 as shown in Table VII.

"The R.F.F. projection of total paper and board production for the year 2000 indicates a requirement of pulpwood of 264 million standard cords per year compared to 171 million standard cords according to B.S.D.A. requirements. Similarly, an estimate as to the number of large new pulp, paper, and board mills that would be required to produce the quantities of projected paper and board output by these two statistical projections would come to 403 for B.D.S.A. projections compared to 687 based on R.F.F. data (*24*)."

New plants can be designed to incorporate water conservation measures that would be impractical in existing plants. It is becoming a common industrial practice to install several complete water recirculation systems. For example, there may be a system for potable water, one for process water, and one for fresh or brackish cooling water. The process and cooling waters are often treated and recycled effluents. In general, the fresh supply is used only in operations needing water of the highest quality. The effluent, with or without treatment, is then recycled to operations with successively lower quality requirements. The pulp and paper industry has been particularly successful in re-using process water in this way.

The volume of water used in manufacturing pulp, paper, and paperboard products varies widely with the type of product but also among mills making substantially the same items. For example, Mussey (*25*) has noted that in Wisconsin the maximum use of water ranges from twice to 12 times the minimum use. Managements at mills with abnormally high water requirements could benefit by learning how other mills making similar products use water more efficiently.

Operating personnel are sometimes reluctant to make full use of recycled water. Siebert reports (*26*) installation of a clarifier for processing 4.5 million gallons a day of white water from machine savealls. About half of the clear water is pumped back to the mill for process use. The other half is being wasted until stubborn resistance to re-using all of it can be overcome. Almost all of the recovered sludge is re-used in the mill for an average daily saving of $650.

Siebert's experience with board mills has convinced him that re-use of white water in pulp preparation, headboxes, etc., along with clarification and re-use on most showers and restriction of fresh water to one shower, can result in the use of not more than 3000 gal. of fresh water per ton of product in almost all board mills. He points out also that the value of temperature gain should not be overlooked even though it is difficult to estimate in dollars.

It has not been the purpose of this paper to detail the various methods that have been used to conserve water in the pulp and paper industry. Local conditions differ so much from mill to mill that generalizations would not be very helpful. Brown (*27*) has reviewed water conservation practices, and has correctly observed that only complete knowledge of the entire papermaking process, coupled with the necessities of existing situations, can lead to efficient use of water.

One effective stimulus to water conservation has been the development of regulations to abate stream pollution. The unreasonable use of streams for waste disposal can destroy the value of surface water for downstream users. Treatment of waste water by the pulp and paper industry is recovering valuable material formerly lost. Indeed, in some instances, efficient recovery of fiber is essential to maintenance of a competitive position. Public pressure for more and more effective waste treatment is bound to continue, not only to conserve water, but to improve recreational opportunities.

Ackerman and Löf have written a comprehensive review of ways in which advancing technology can be depended upon to expand the availability of water supplies. Among other things, they have concluded that re-use of water by industry should be one of the most important technological developments of the next 10 to 25 years. They state that increasing industrial re-use of water to 300%, from the current average of 100%, will permit twice the present output of goods without a significant increase in industrial fresh-water demand (*28*). This would tend to support the conclusion that predictions of a very large growth of industrial water demands are not justifiable.

SUMMARY

Analysis of various estimates of future industrial water requirements has demonstrated that water supplies for the nation as a whole will be adequate for many years to come. On the other hand, there are many parts of the country where fresh water is perenially or sporadically in short supply. Water conservation is essential to industrial operations in areas of shortage, but conservation even where water is plentiful is generally economically advantageous. The record of the pulp and paper industry in conserving water through re-use is better than the industrial average, but the projected expansion of this industry suggests that even more efficient use of water may be necessary in the future.

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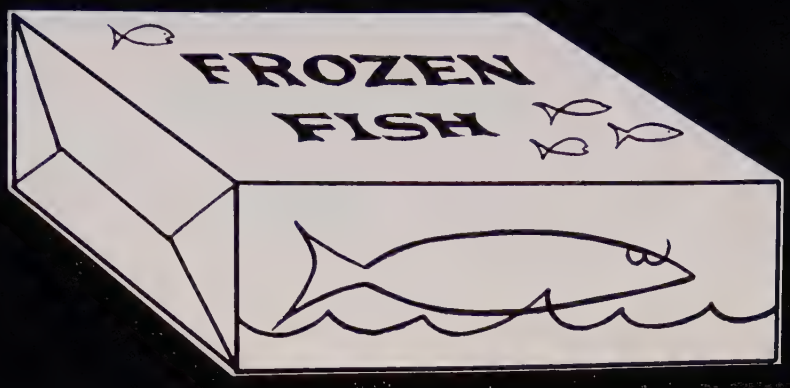
Presented at the 15th Engineering Conference of the Technical Association of the Pulp and Paper Industry, held in Jacksonville, Fla., Oct. 24–28, 1960.



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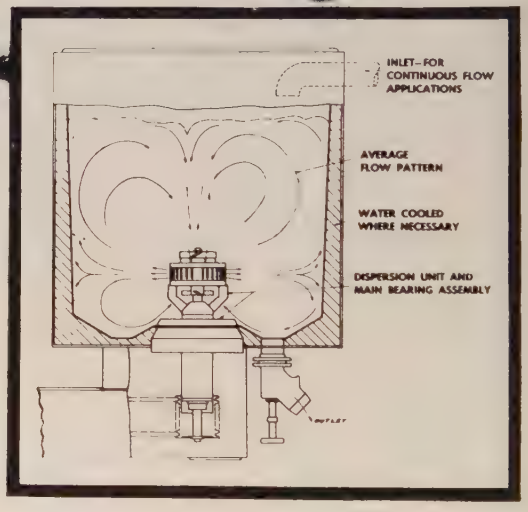
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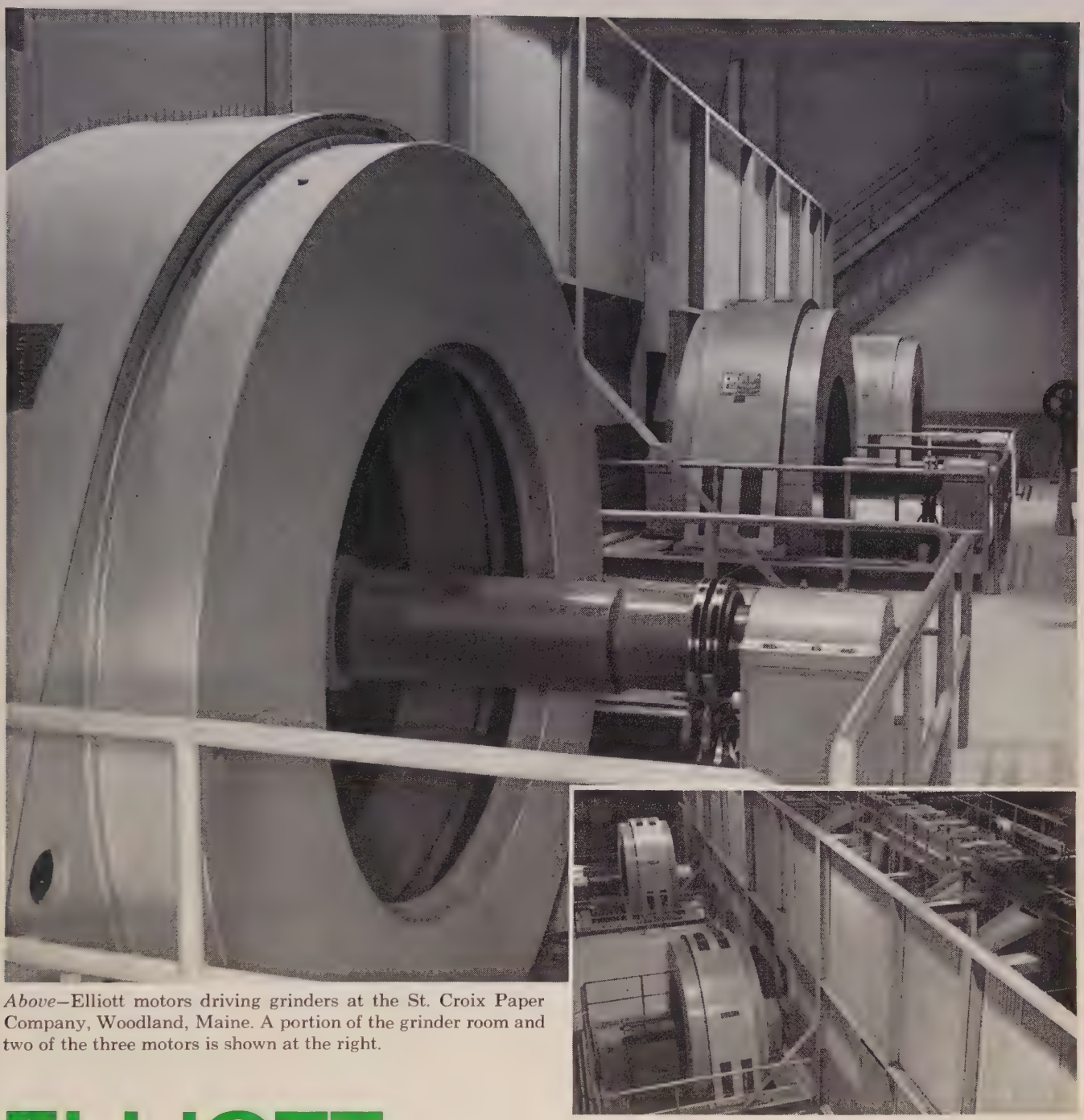

Above—Elliott motors driving grinders at the St. Croix Paper Company, Woodland, Maine. A portion of the grinder room and two of the three motors is shown at the right.

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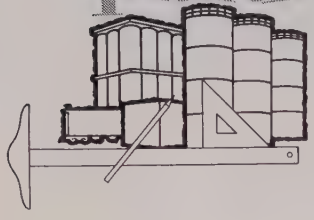

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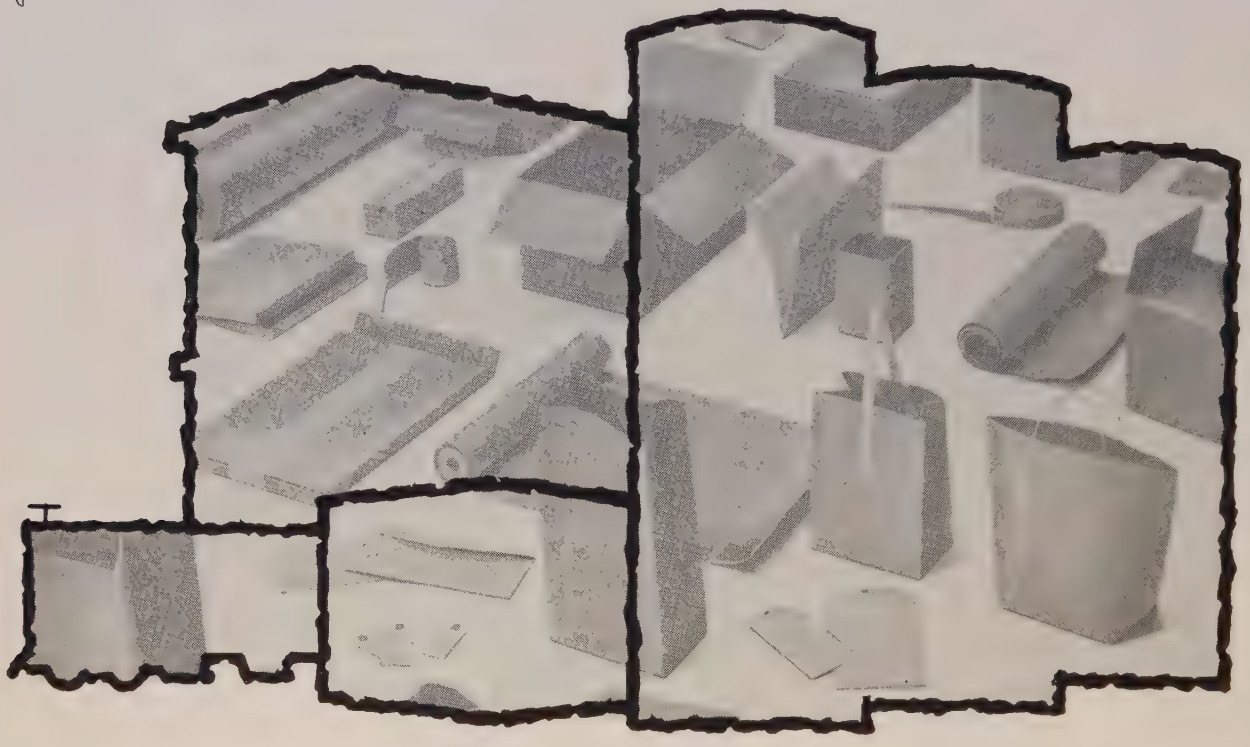

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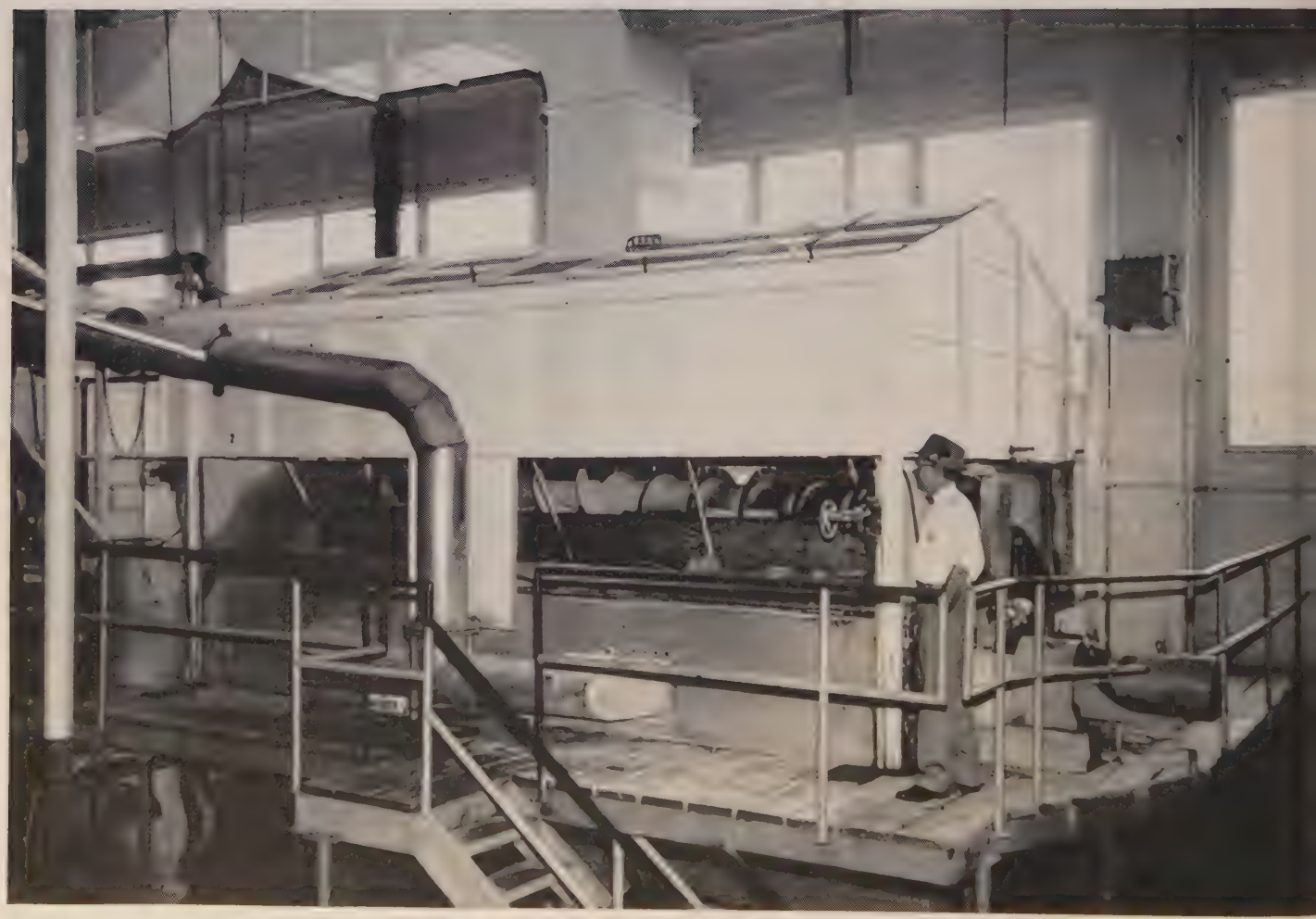

OLIVER DENHARD DISCHARGER on 8′ x 16′ groundwood washer at Elk Falls Company Limited, division of Crown Zellerbach Canada Limited, Vancouver Island, B.C. Pick-up roll is 15½″ O.D. Unit operates at a speed of 4 R.P.M. on the washer, handling up to 200 AD tons daily.

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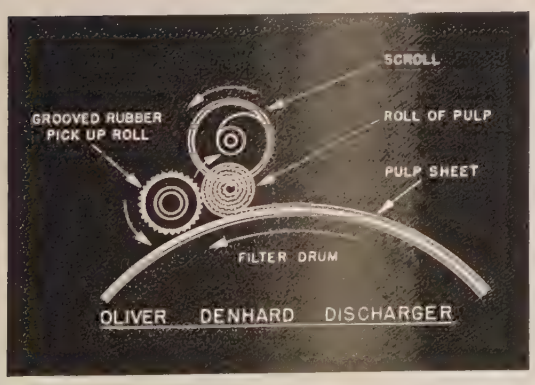
For example, Elk Falls Company Limited, a division of Crown Zellerbach Canada Limited, has recently put into operation a Denhard Discharger on a groundwood washer handling 160 AD tons daily. A second unit has been ordered. A Denhard Discharger of similar size is also being used on a vacuum groundwood thickener, permitting cylinder speeds in excess of 7½ R.P.M.

The Denhard Discharger on a groundwood washer makes possible a higher discharge consistency—in the order of 8 to 9% AD—than the conventional hydraulic doctor. Water consumption of the hydraulic doctor is eliminated, resulting in a higher stock temperature and a reduction in the amount of slime formation.

If you already have an Oliver Denhard Discharger in operation with a groundwood thickener, use of this new, larger size may permit a faster cylinder speed and higher capacity. Installation in place of a conventional hydraulic doctor on a groundwood washer will pay immediate dividends in terms of higher discharge consistency and saving of water. Write to Dorr-Oliver Incorporated, Stamford, Conn.



SIMPLE OPERATION of the Oliver Denhard Discharger is shown in this diagram. A grooved rubber pick-up roll starts the pulp sheet rolling up on itself like a carpet. A scroll carries the pulp to either end of the unit for discharge. Since nothing touches the facing wire but the pulp itself, maximum wire life is assured, together with a minimum of wire blinding.

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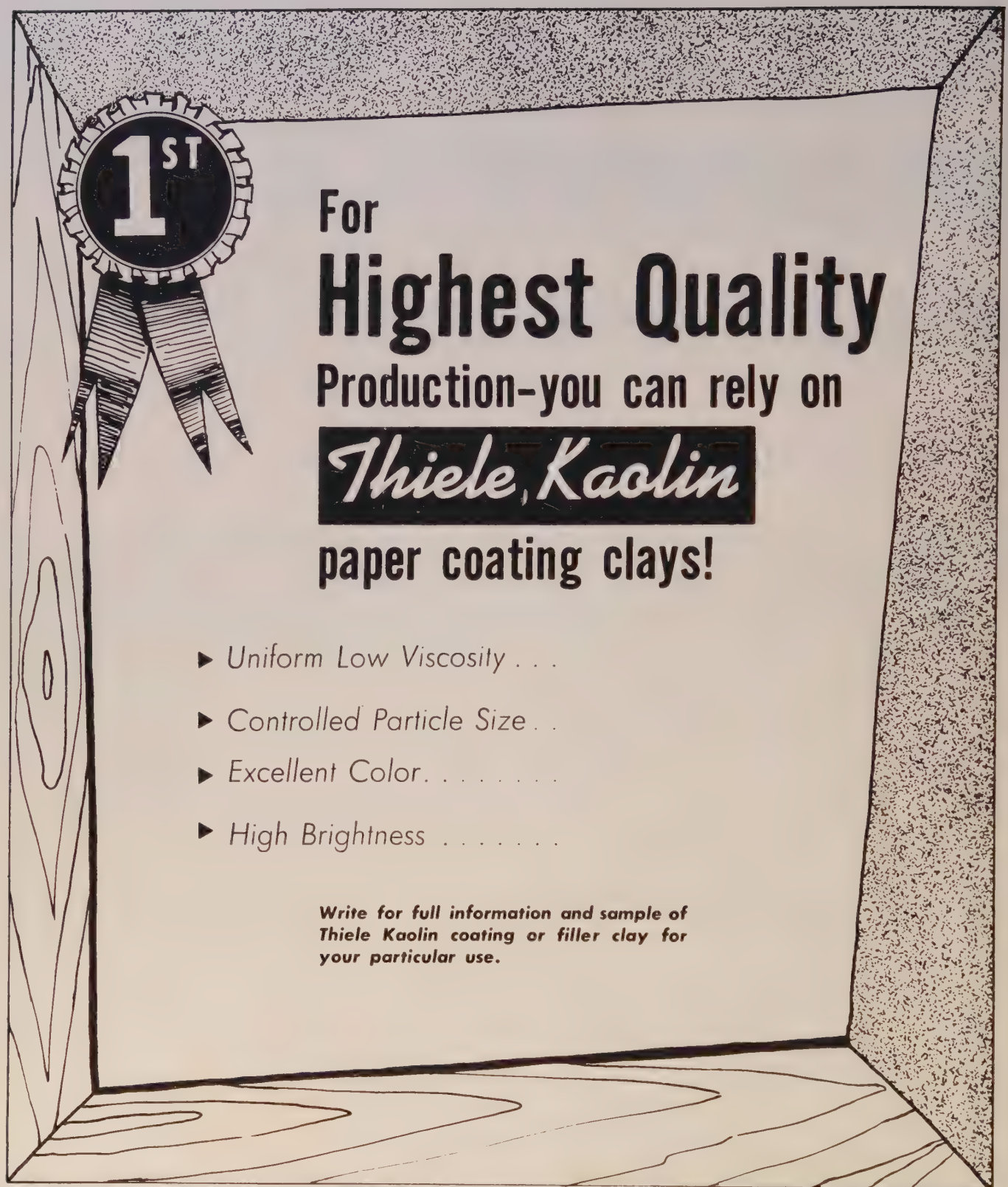
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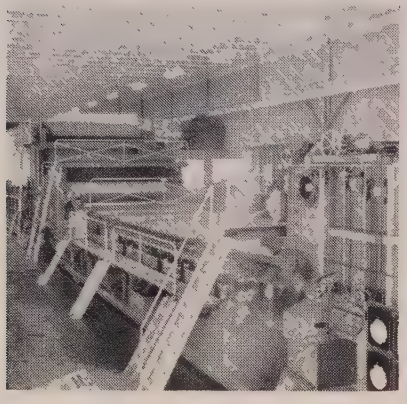

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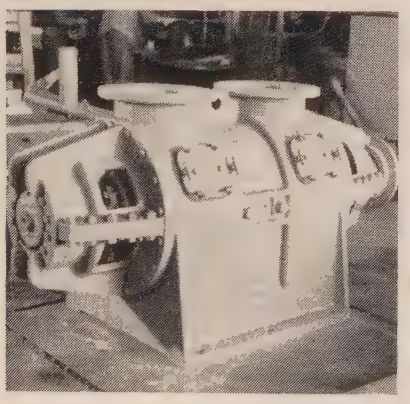

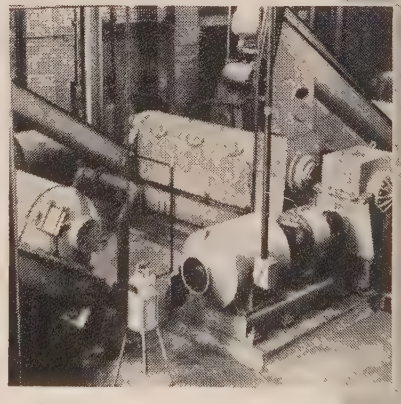

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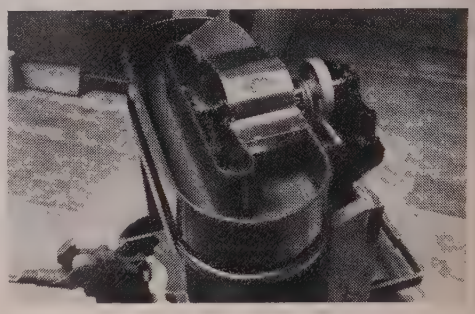

Testing Equipment for the Industry

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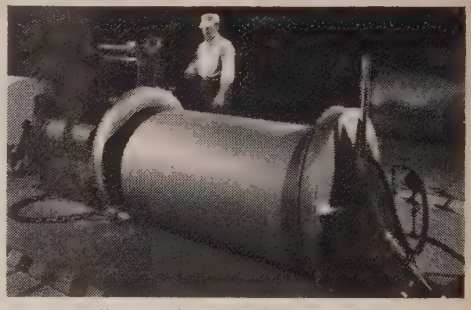

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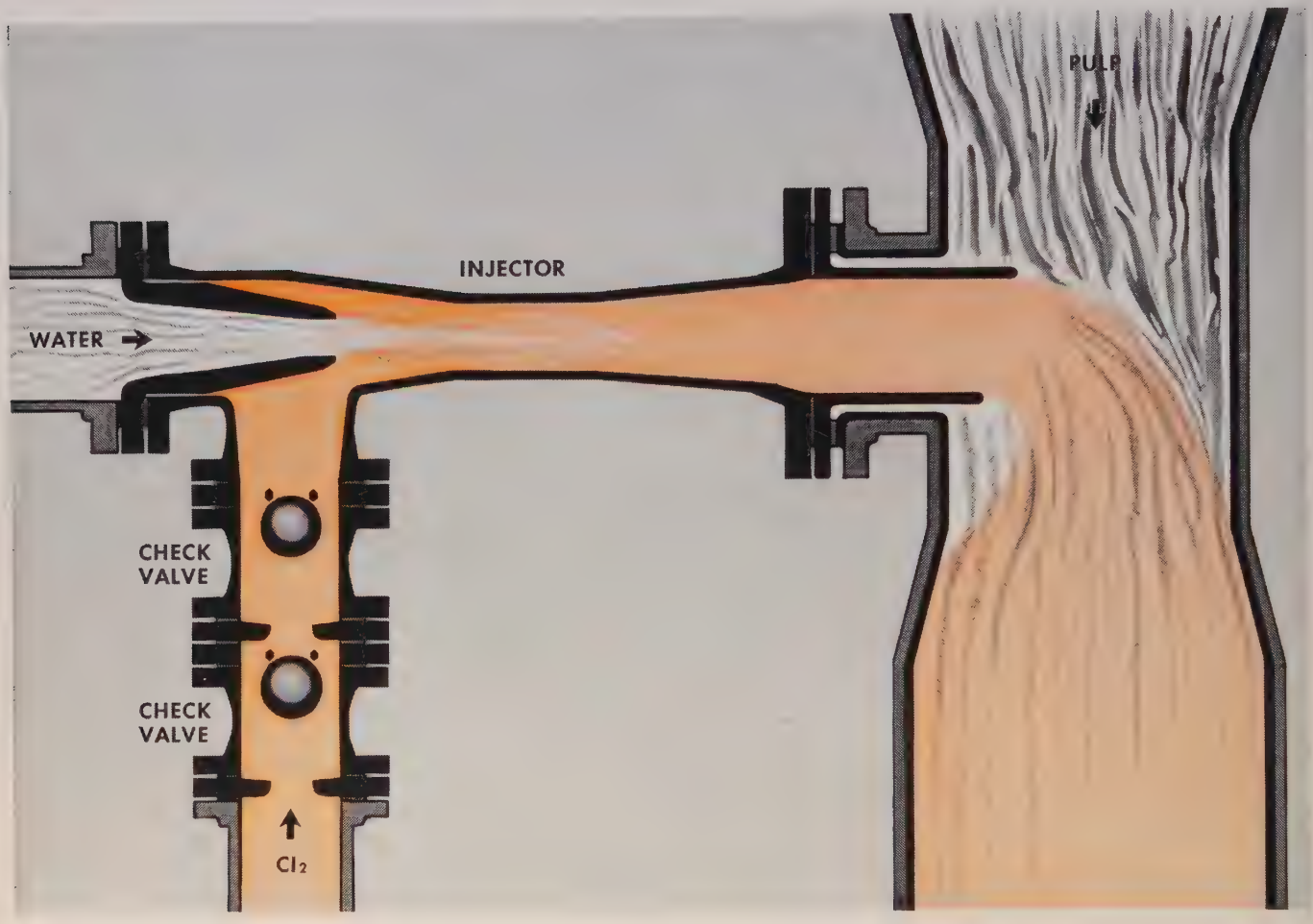
The trademark of quality

PENNSYLVANIA INDUSTRIAL CHEMICAL CORPORATION

CLAIRTON, PENNSYLVANIA

ONE STEP TO BETTER PULP CHLORINATION

A TOUGH NEW CHLORINE INJECTOR



- **Engineered for chlorine**
- **Tough, corrosion resistant**
- **Effective chlorine atomization**
- **Dependable check valve**

Here is a rugged new injector, engineered specifically for safe, efficient chlorine injection into pulp stock.

Two types of construction are available: (1) steel body protected against corrosion and with a PVC insert; (2) a unit fabricated entirely of Hetron® polyester resin reinforced with glass fiber, tough materials, free from corrosion and fire-retardant.

The long, smooth venturi permits maximum use of water energy to atomize the chlorine for rapid, uniform solution in pulp slurries.

Dependable double check valves protect against a water backup into the chlorine system.

Hooker technical service engineers will be happy to help you design and install a complete system. They can also advise you on the other important steps of Hooker pipeline mixing, redox control, and retention time control.

Write for a descriptive bulletin on the new Hooker chlorine injector.

HOOKER CHEMICAL CORPORATION

2102 Forty-seventh Street, Niagara Falls, N. Y.

Sales Offices: Buffalo Chicago Detroit Los Angeles New York Niagara Falls Philadelphia Tacoma Worcester, Mass.
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HOOKER CHEMICALS PLASTICS

fmc®

puts paper through its paces for alkali users!

With our Princeton Research Center now in full operation, FMC is prepared to offer the paper industry better-than-ever assistance with processing problems.

Research staffs of all three divisions of FMC's Inorganic Chemicals Department now work as a team in one of the best-equipped paper laboratories outside of the paper industry. Here, these paper specialists duplicate in miniature all basic steps of paper manufacturing and evaluate results with a complete range of performance tests.

This exceptional extra service is available for the asking. Next time you have a problem call our nearest office.

CAUSTIC SODA—50% and 73% Liquid, Regular and Rayon Grades; Flake, Solid and Ground
SODA ASH—Light, Intermediate and Dense Grades

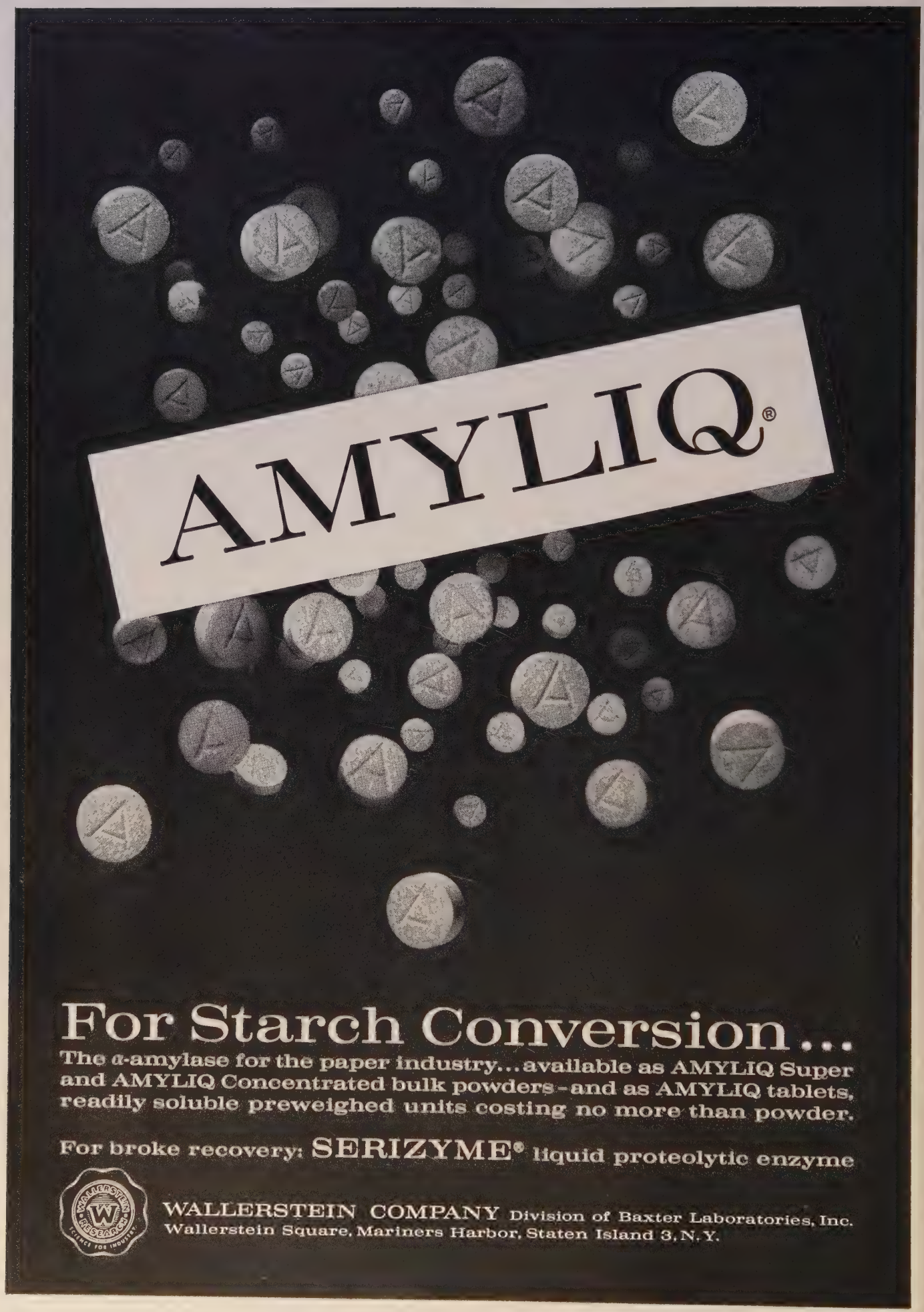
Putting Ideas to Work

FOOD MACHINERY AND CHEMICAL CORPORATION

Chlor-Alkali Division

General Sales Offices:
161 E. 42nd STREET, NEW YORK 17

fmc FOOD MACHINERY AND CHEMICAL CORPORATION ®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For Starch Conversion...
The α-amylase for the paper industry...available as AMYLIQ Super and AMYLIQ Concentrated bulk powders - and as AMYLIQ tablets, readily soluble preweighed units costing no more than powder.
For broke recovery: SERIZYME® liquid proteolytic enzyme
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Wallerstein Square, Mariners Harbor, Staten Island 3, N.Y.

Paper sculpture by Giuseppe Baggi

Pulp from Gottesman means...

TECHNICAL SERVICE!

Bleached and Unbleached Sulphite • Bleached Hardwood • Groundwood
Bleached, Semi-Bleached, and Unbleached Kraft

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PULP PAPER EXPORT CNC

Established 1886

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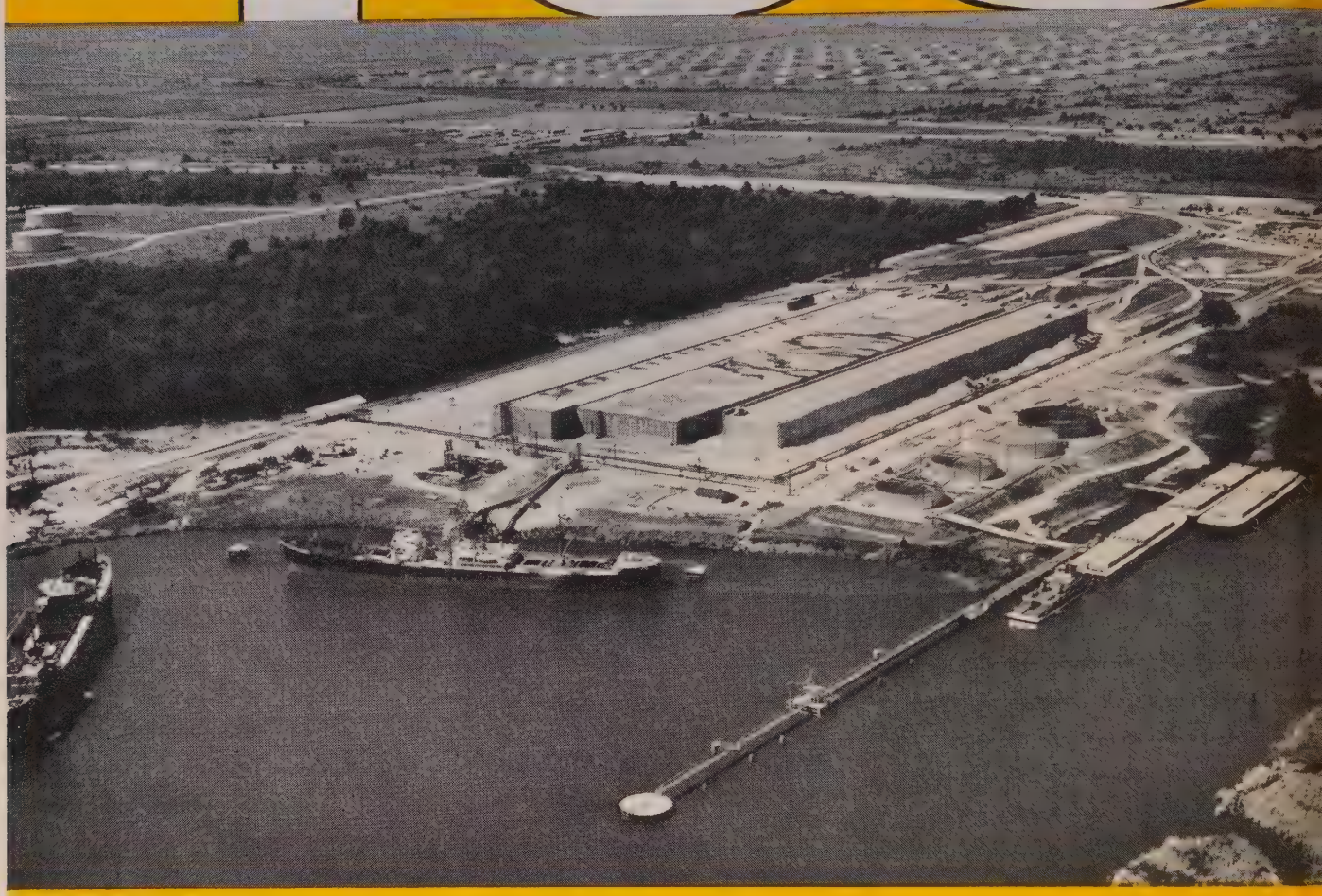
Gottesman & Company Aktiebolag, Stockholm, Sweden • Central National-Gottesman Limited, London, England • Representatives in 55 Leading World Markets

TGS



RAIL AND WATER SHIPMENTS

In order to better serve our far-flung customers in the process industries, we have developed at Beaumont, Texas the most modern Sulphur storage, handling and loading facilities in the world. This terminal and shipping center is now receiving deliveries from all four major TGS properties in Texas: Spindletop, Moss Bluff, Newgulf, and Fannett – the most recent mine to be developed.

. . is now operating at **Beaumont, Texas**

THE WORLD'S NEWEST SULPHUR TERMINAL

. . . for Solid Sulphur

. . . for Molten Sulphur

A few of the design features of this terminal may be of interest:

- It receives, stores, and loads both solid and molten sulphur.
- It can load simultaneously 1 dry cargo ship of 20,000 tons capacity, 3 molten sulphur barges and 1 molten sulphur tanker. There's a holding dock where a second cargo ship can be tied up. The barge basin will accommodate 12 sulphur barges.
- Storage capacity totals 31,000 tons for molten sulphur and 1,000,000 tons for solid sulphur. Loading capacity for molten sulphur ranges up to 3,000 tons/hour, tanker and barge simultaneously; for solid sulphur the loading capacity is 1,200 tons/hour into ship or barge.

This development at Beaumont is but another step in the broadening delivery service program now being carried out by TGS. Regional distribution centers, handling molten sulphur, are already in operation at Cincinnati, St. Louis and Tampa. Coinciding with the full operation of our main terminal at Beaumont will be the opening early in 1961 of two coastal terminals at Carteret, New Jersey, (26,000 tons molten sulphur storage) and Norfolk, Virginia (20,000 tons). Other terminals are in the planning stage.

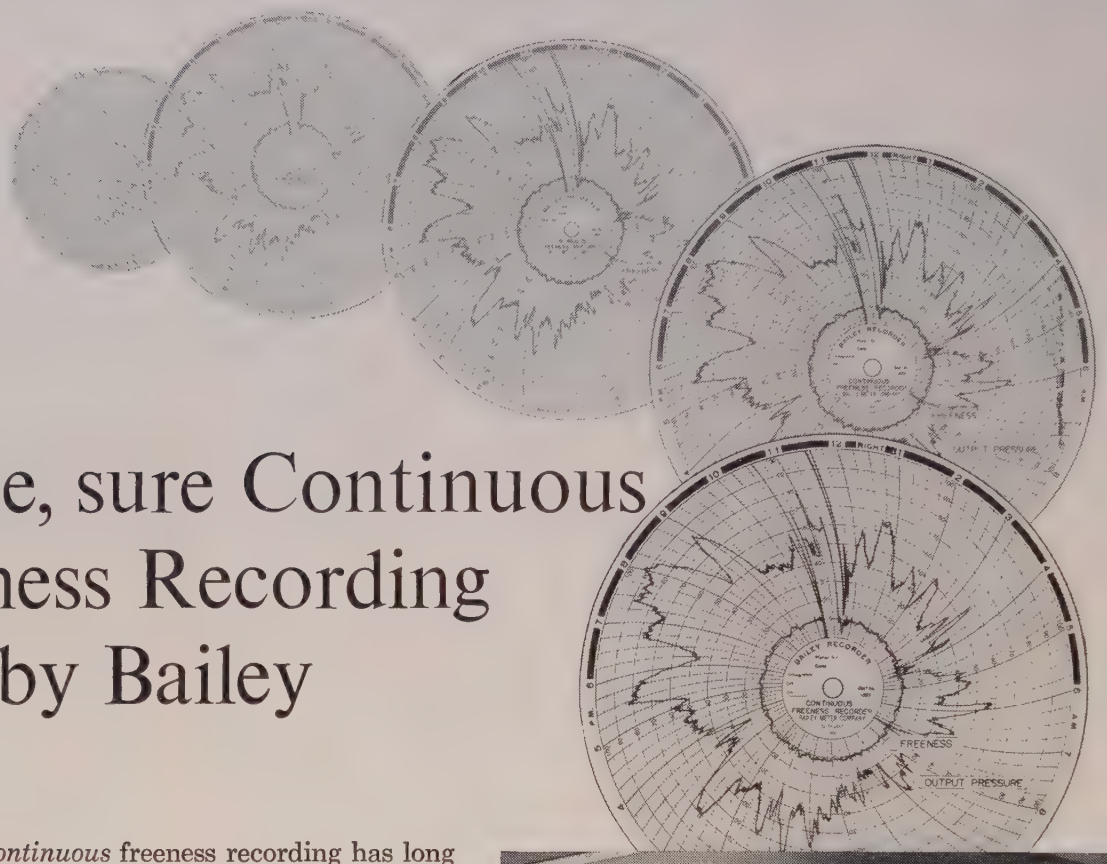
TEXAS GULF SULPHUR COMPANY

75 East 45th Street, New York 17, N. Y.

811 Rusk Avenue, Houston 2, Texas

Sulphur Producing Units: Newgulf, Texas • Spindletop, Texas Moss Bluff, Texas • Fannett, Texas • Worland, Wyoming • Okotoks, Alberta, Canada.

Now...proved in continuous operation...



simple, sure Continuous Freeness Recording by Bailey

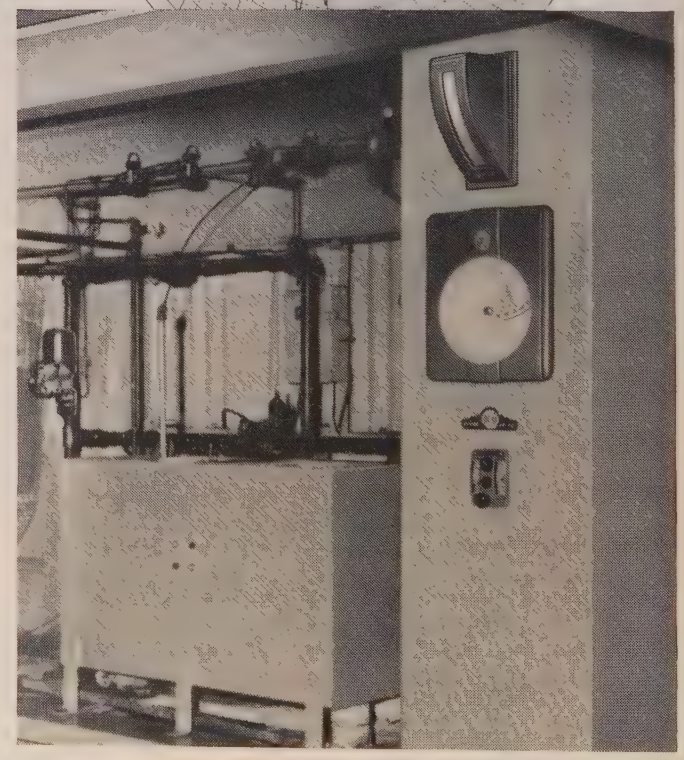
Dependable, *continuous* freeness recording has long been an objective of the pulp and paper industry.

Today it is a fact.

The Bailey Continuous Freeness Recorder, based on simple principles and utilizing equipment well-known by the pulp and paper industry, now provides a means for dependable, continuous measurement of freeness, proved in successful, continuing service for more than a year.

Its operation enables more accurate control of pulp stock characteristics...automatic control of refiners and jordans for sustained product quality. Performance is trouble-free . . . maintenance, negligible. Your Bailey Engineer will be glad to give you details. Call your nearest Bailey District Office, or write.

P151-1



Bailey Continuous Freeness Recorder in operation at a Southern newsprint plant.

PULP AND PAPER DIVISION

BAILEY METER COMPANY

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In Canada — Bailey Meter Company Limited, Montreal

BAILEY METERS

Which of these 3 products and services can you use from BECCO?

New Cold Caustic Bleach Process

Looking for a way to use greater amounts of low-cost, more plentiful pulp—without capital investment for bleach equipment? Then let a Becco Sales Engineer show you our new technique* which allows you to bleach in the same equipment regularly used for the manufacture of cold caustic pulp.

In this new process, peroxide bleach liquor is added at the Bauer Refiner, and bleaching occurs during the refining operation. Bleach response depends on refiner densities.

Up to 20 points brightness increase has been obtained in commercial operations to date, and with no additional steam costs, no holding time, and no excessive chemical costs.

Becco can assist you immediately in setting up a production run and evaluating results. First step: use the coupon to let us know you're interested.

*—Patent Pending

BECCO fmc

BECCO CHEMICAL DIVISION, FMC
161 East 42nd Street, New York 17, N. Y.
Dept. T-H

Gentlemen:
Please have a Sales Engineer give me more information on Becco's Cold Caustic Bleach Process.

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FIRM_____

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CITY_____

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We got 'em—
You can have 'em!
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Years of experience in paper and pulp processing have produced a library of technical information which is available in individual bulletins, free on request. Use the coupon below to let us know which you'd like to receive.

No. 31 — Groundwood Bleaching Variables — A Statistical Approach.

No. 32 — H_2O_2 Bleaching of Chemicals and Mechanical Pulps.

No. 47 — Peroxide Bleaching of Pulps.

No. 48 — High-Density Pulp Bleaching.

No. 64 — Development Studies on Last-Stage H_2O_2 Bleaching of Alkaline Pulps.

No. 65 — Peroxide Bleaching of Southern Pulps.

No. 66 — Becco Laboratory Procedures for Pulp Bleaching, 1955 Ed.

No. 91 — Peroxide Bleaching of Chemi-Mechanical Hardwood Pulps.

No. 92 — Peroxide Bleaching of Chemical Pulps.

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Gentlemen:
Please send me a copy of each of the following bulletins:

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FIRM_____

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CITY_____

ZONE____ STATE_____

Problems in handling Hydrogen Peroxide

?

Becco's Four-Fold Engineering Service Program—offered free—includes:

1. Comprehensive survey of your facilities.
2. Specific proposal with recommendation of proved equipment and where it is obtainable.
3. Installation supervision by Becco.
4. Periodic inspection and permanent service.

Can you use this free Becco help, based on more years of experience with bulk handling of H_2O_2 than any other manufacturer? Use the coupon to let us know.

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Gentlemen:
Please tell me more about your Four-Fold Engineering Service.

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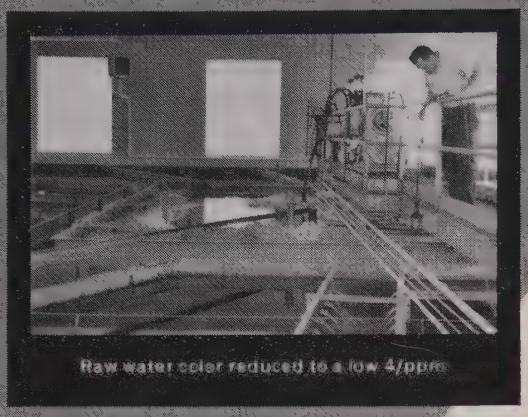
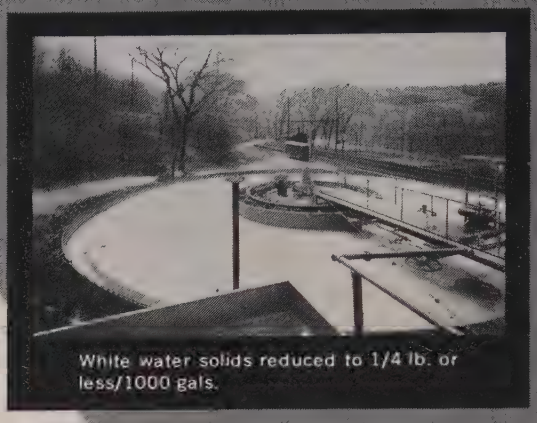
PQ SOLUBLE SILICATES for the Pulp and Paper Industry

FROM RAW WATER.....TO WHITE WATER

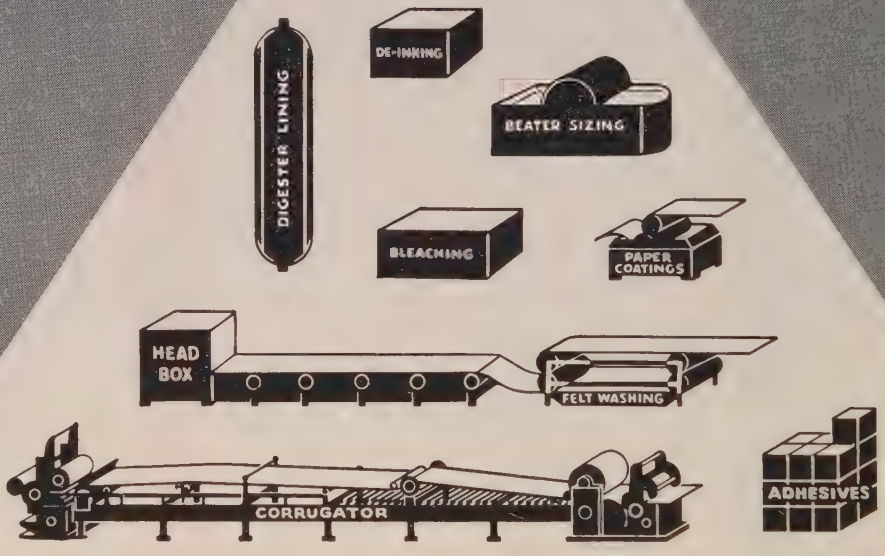


Raw water color reduced to a low 4/ppm

AND PROCESSES IN BETWEEN



White water solids reduced to 1/4 lb. or less/1000 gals.



One of these uses for soluble silicates can help you to improve product or profit—for example:

- PQ silicate as a buffer for peroxide bleaching is the answer for controlling pH to give better brightness.
- With alum in the beater PQ silicate reduces beating time, produces a firmer sheet with improved finish.
- Fiber and filler retention on both cylinder and Fourdrinier machines is increased with PQ silicate.
- Stixso silicates add structural strength—(10-15% increased compression) to corrugated board.

Check any of the uses in which you are interested and we will be pleased to send you detailed bulletins and further information relating specifically to your operations.

PHILADELPHIA QUARTZ COMPANY
1144 Public Ledger Building, Philadelphia 6, Pa.

SOLUBLE SILICATES
STIXSO ADHESIVES

Associates: *Philadelphia Quartz Co. of Calif., Berkeley & Los Angeles, Calif., Tacoma, Wash.; National Silicates Limited, Toronto & Valleyfield, Canada. Distributors in over 65 cities.*

TRADEMARKS REG. U.S. PAT OFF

PQ PLANTS: ANDERSON, IND.; BALTIMORE, MD., BUFFALO, N. Y.; CHESTER, PA., JEFFERSONVILLE, IND.; KANSAS CITY, KANS.; RAHWAY, N.J.; ST. LOUIS, MO.; UTICA, ILL.

These swatches represent two entirely different titanium dioxide paper coatings.

One is an anatase grade, the other is a rutile grade.

CAN YOU TELL WHICH IS WHICH?

These two swatches of TiO_2 pigment have been applied by silk screen so that you can compare them quickly on this printed page. The formulas are nearly identical except that one contains a rutile grade, the other new *LD-C* anatase.

Although you'll achieve superior coating with regular paper mill machinery, the proof is there . . . new Glidden *LD-C* (on the right) has properties comparable to the rutile. The brightness of anatase is combined with the ease of dispersion and low viscosity features of rutile.

New *LD-C* is equally well suited for on and off machine, size press and calender coating. Compatible with all other common paper coating pigments and adhesives.

Being an anatase grade, new *LD-C* is for coating of all nonwaxing, plain and printed paper and board. And *LD-C* is priced as an anatase. Some users are obtaining savings of up to 2¢ per pound.

Higher machine speeds, heavier coating weights and other advantages are inherent in new *LD-C*. To get the full story, or samples, call your Glidden representative or our Baltimore headquarters.

GLIDDEN ZOPAQUE® LD-C

anatase grade TiO_2 especially developed for paper coating

QUALITY Glidden PRODUCTS

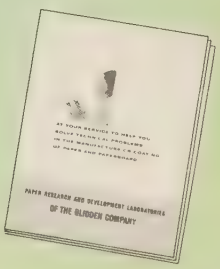
THE GLIDDEN COMPANY

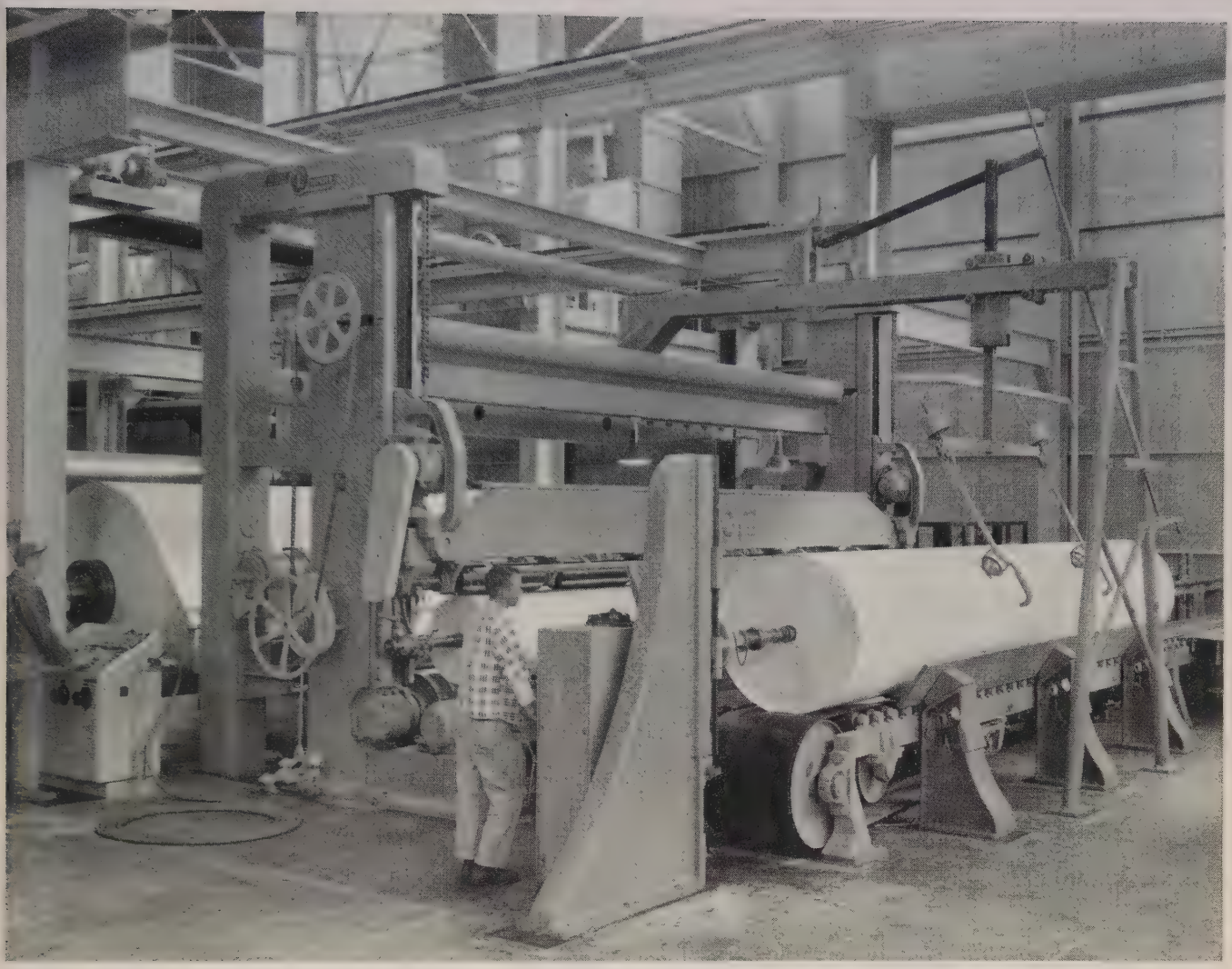
FINEST PIGMENTS FOR INDUSTRY

Chemicals Division • Pigments and Color Department

Baltimore 26, Maryland

MANY GLIDDEN TECHNICAL FACILITIES ARE AT YOUR SERVICE for development or testing work in paper. Write for this new brochure—just off the press—*Paper Research and Development Laboratories.*





S. R. CHRISTENSEN

Bowaters Southern Paper Corporation No. 4 Machine Winder—Design Speed 6000 FPM

Beloit Model "L-24" Newsprint Winder

If a new winder is included in your future planning, take advantage of Beloit Eastern's many years' experience in building high-speed winders to meet the most exacting mill requirements. No matter what the size, speed, or trim, one of Beloit Eastern Corporation's family of winders will do the job. These winders provide an excellence of winding unsurpassed in the paper industry. Practical mill experience and fine craftsmanship integrate winder, tension control, slitting, drive and roll and shaft handling into a single system with unit responsibility. Look to Beloit Eastern Corporation for the finest in finished product processing equipment.

FINISHED PRODUCT PROCESSING EQUIPMENT

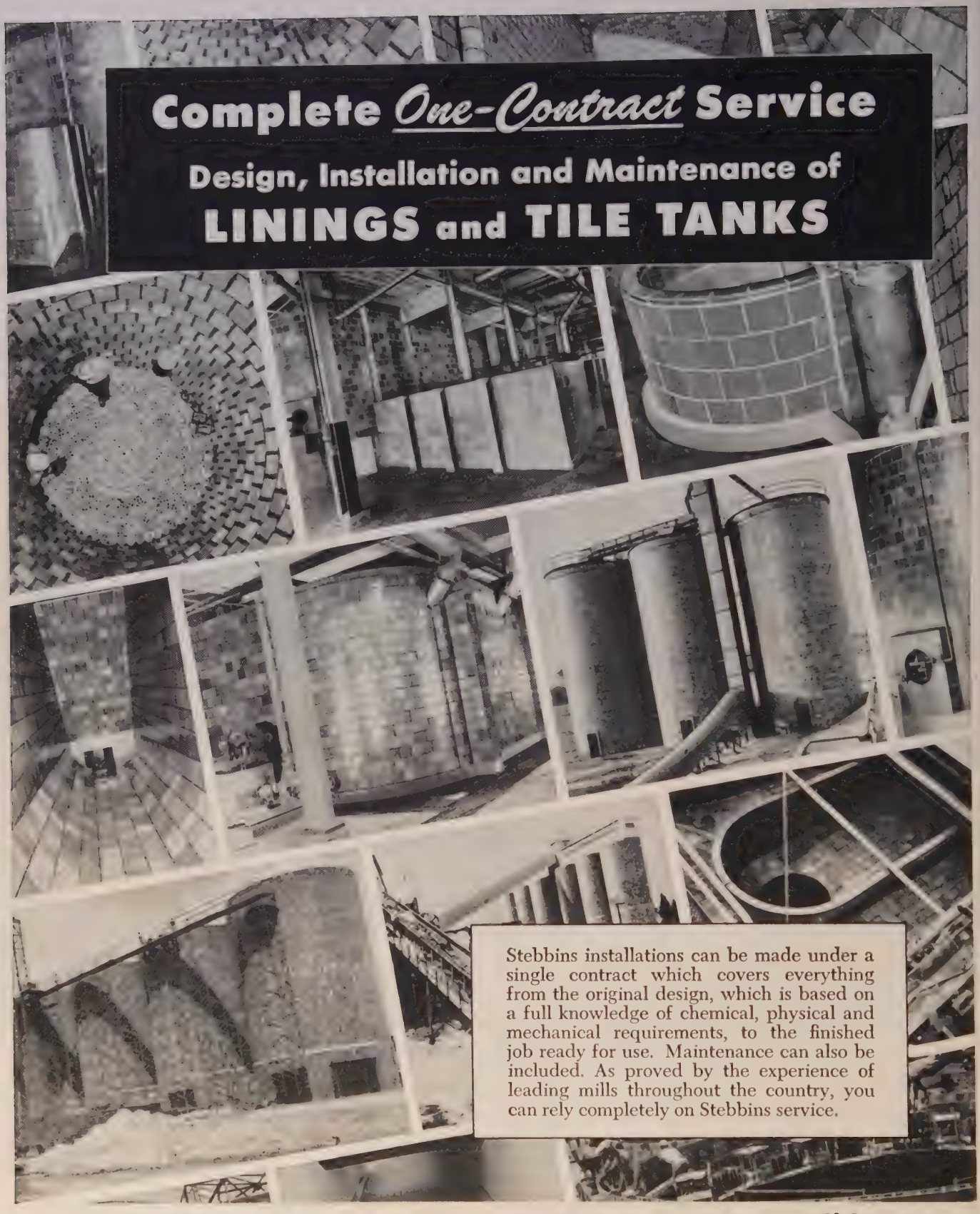
Winders • Reclaim Winders • Cutters Slitters • Supercalenders • Roll Wrappers • Roll Lowering Tables Roll and Shaft Handling Equipment Conveyors • Unwind Stands and Tru-Tension Controls • and other equipment for the paper and allied industries.

BELOIT EASTERN PAPER MACHINERY DOWNINGTOWN

Member Beloit Group

BELOIT EASTERN CORPORATION

DOWNINGTOWN, PENNSYLVANIA



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Design, Installation and Maintenance of LININGS and TILE TANKS

Stebbins installations can be made under a single contract which covers everything from the original design, which is based on a full knowledge of chemical, physical and mechanical requirements, to the finished job ready for use. Maintenance can also be included. As proved by the experience of leading mills throughout the country, you can rely completely on Stebbins service.

SINCE 1884
Specialists in
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Installation
and Servicing
of Linings and
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SEMCD

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CANADIAN STEBBINS ENGINEERING & MANUFACTURING CO., LTD.

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GOING UP!

...up to Cyanamid Paper Chemicals Department's exciting and informative 'Chemicals for Progress in Paper' exhibit. New location—East Ballroom, second floor, Hotel Commodore; same old-fashioned welcome!

Our large presentation area will offer the latest facts on the ever-growing consumer markets for paper products. Samples of wet-strength paper products will be on display.

Again, as in the past, you will find Cyanamid Salesmen and Technical Personnel available to answer your questions. You will see how the use of chemicals imparts improved properties in paper—resulting in expanded marketing possibilities.

The Paper Chemicals Department exhibit will be open in the East Ballroom every day during TAPPI Week. Our Hospitality Suite—Room 2100 at the Hotel Commodore—will also be open for your pleasure during the entire proceedings.

CYANAMID

American Cyanamid Company
Paper Chemicals Department
30 Rockefeller Plaza, New York 20, N.Y.

Announcing a unique achievement in the field of quality control and statistical testing . . . **THE NEW INSTRON DYNAMIC DIGITAL SYSTEM**

INSTRON'S new dynamic digital system brings dramatic savings in time and work to the field of materials testing. For the first time, tests can be conducted and recorded at high speed without the need for time-consuming chart evaluation.

This new system selects values of desired characteristics from the load-elongation curve of the material being tested, stores the information in magnetic-core memory units and, on completion of the test, prints them out on a special high-speed serial-entry printer. Total time required for a complete test and printing of results is less than 15 seconds.

The digital system can be programmed to convert extension, energy, load or stress, modulus, yield point, hysteresis and other parameters directly into numerical values, in any units desired. The fast, efficient printer delivers information in ready-to-use form, also provides for totalizing. Digital INSTRON equipment, field tested for over two years, more than doubles testing output. The time-saving features of this system allow larger samplings for more meaningful results. Errors in reading charts and writing down data are eliminated. All the operator does is place the sample in the jaws and push a button. The system does the rest.

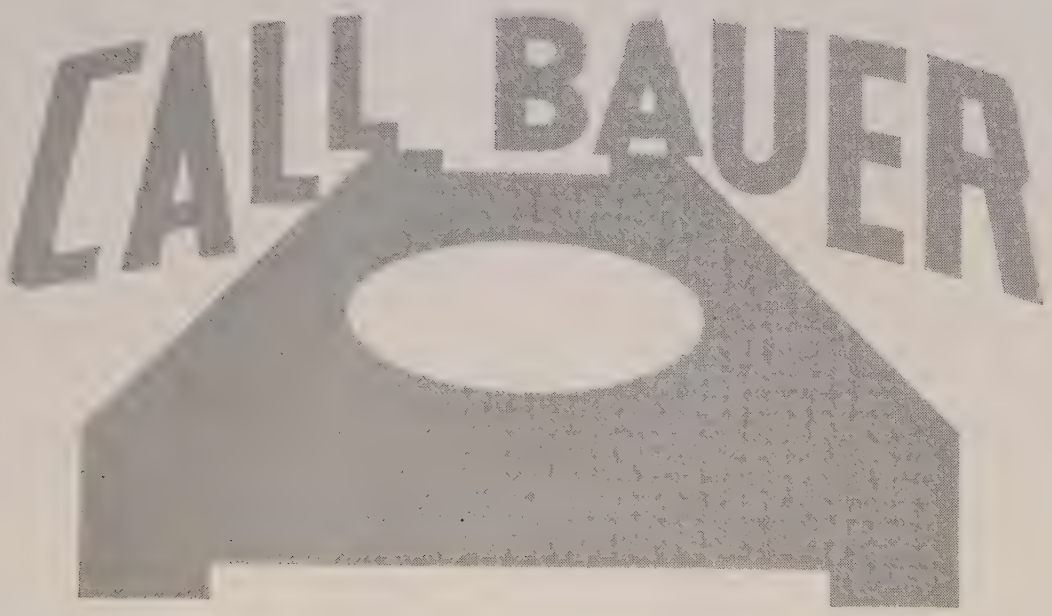
The system shown here combines the new digital printout system with an optional strip-chart recorder. Thus, it's two machines in one — offering printed figures for statistical analysis plus the actual corresponding curve for detailed visual study of materials characteristics.

Think about it. Here are new possibilities in volume testing, quality control and statistical analysis. Here is a new system to bridge the gap between manual tabulation of data and high-cost computer operations. Here is the opportunity to do more . . . find out more . . . do it more accurately . . . in less time.

We invite you to send for full information. Just write:

INSTRON
ENGINEERING CORPORATION
2500 WASHINGTON STREET, CANTON, MASS.

TO UP-GRADE PRODUCTION



Cleaner stock . . . CENTRI-CLEANERS

Improved fiberizing of chips, higher machine speeds . . . DOUBLE REVOLVING DISC REFINERS

Continuous or rapid cycle cooking and impregnation . . . DIGESTERS

Final stock preparation . . . PUMP THROUGH REFINERS

Liquor removal . . . PRESSAFINERS

Automated high yield systems . . . BAUERITE

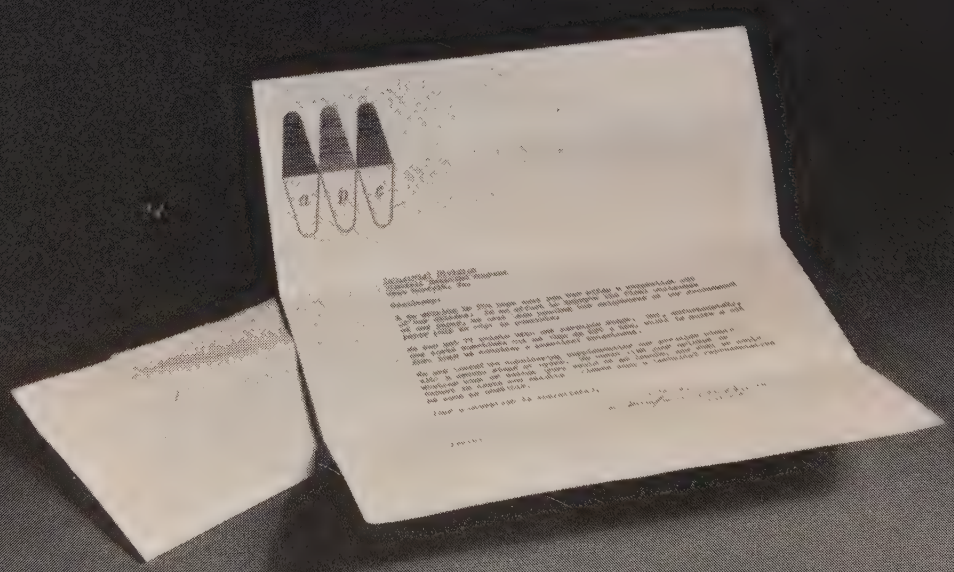
THE *Bauer* BROS. CO.

Springfield, Ohio

IN CANADA: THE BAUER BROS. CO. (CANADA) LTD.
Brantford, Ontario

Another example of "Virginia" nationwide technical service

"We can get 77 points with one peroxide stage ...but costs sometimes hit $25 a ton... we are considering a second stage of hydro ...send a technical representative."



Fortified with facts and field experience, a "Virginia" technical representative called on this paper mill. After a careful analysis of the entire operation, he sat down with the management to thrash the problem out.

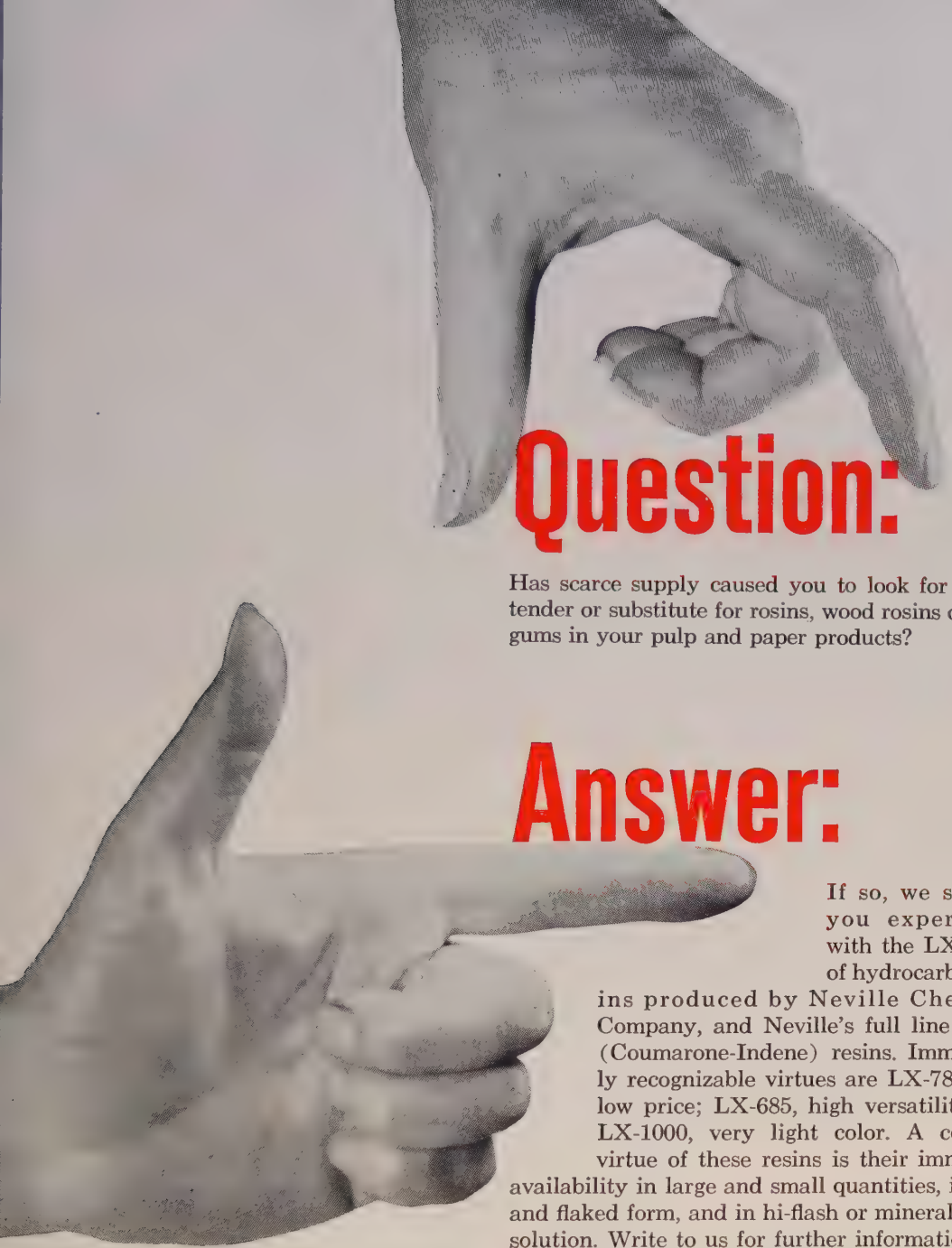
The big trouble was they had reached the flat point in the brightness-concentration curve of the peroxide. To pick up one brightness point they were using an extra 1% of peroxide and paying a premium of around $4. Our man pointed out that at the same cost they could pick up five brightness points by means of a second stage of zinc hydrosulfite. The mill agreed to a trial and equipment was brought in for the second stage. The mill paid for nothing but the actual hydro used. The results proved highly satisfactory, the pulp attaining a degree of brightness that put the mill in a very advantageous competitive position.

If you wish the facts on 2-stage bleaching of groundwood pulp, using hydro for the second stage, wire, phone or write us. We will send data—or, if you prefer, a top-notch "Virginia" technical man. Industrial Division, VIRGINIA SMELTING COMPANY, Dept. 398, West Norfolk, Va.

VIRGINIA Chemicals ®

Field Offices: New York • Boston • Chicago • Atlanta
Asheville • Philadelphia • Akron • Seattle • Memphis

Available in Canada and many other countries



Question:

Has scarce supply caused you to look for an extender or substitute for rosins, wood rosins or ester gums in your pulp and paper products?

Answer:

If so, we suggest you experiment with the LX series of hydrocarbon resins produced by Neville Chemical Company, and Neville's full line of C-I (Coumarone-Indene) resins. Immediately recognizable virtues are LX-782, very low price; LX-685, high versatility; and LX-1000, very light color. A common virtue of these resins is their immediate availability in large and small quantities, in solid and flaked form, and in hi-flash or mineral spirits solution. Write to us for further information.

Neville Chemical Company · Pittsburgh 25, Pa.

NEVILLE®

This new, continuous pulp digester was built by Graver for a leading paper-making equipment manufacturer to help make paper better and faster. Fabricated of stainless steel, 48 inches in diameter, 43 feet long, it weighs 20 tons. It will be installed in a Louisiana paperboard mill.

It's another showing of the engineering and productive capacity of Graver to fabricate steel and alloy plate into new designs of processing equipment.

Whatever your needs may be . . . your design, or one engineered in Graver's research and development department . . . look to Graver first for creative engineering and experienced workmanship.

Graver Tank & Mfg. Co.
EAST CHICAGO, INDIANA
PLANTS AND OFFICES THROUGHOUT THE U. S. A. • SINCE 1857

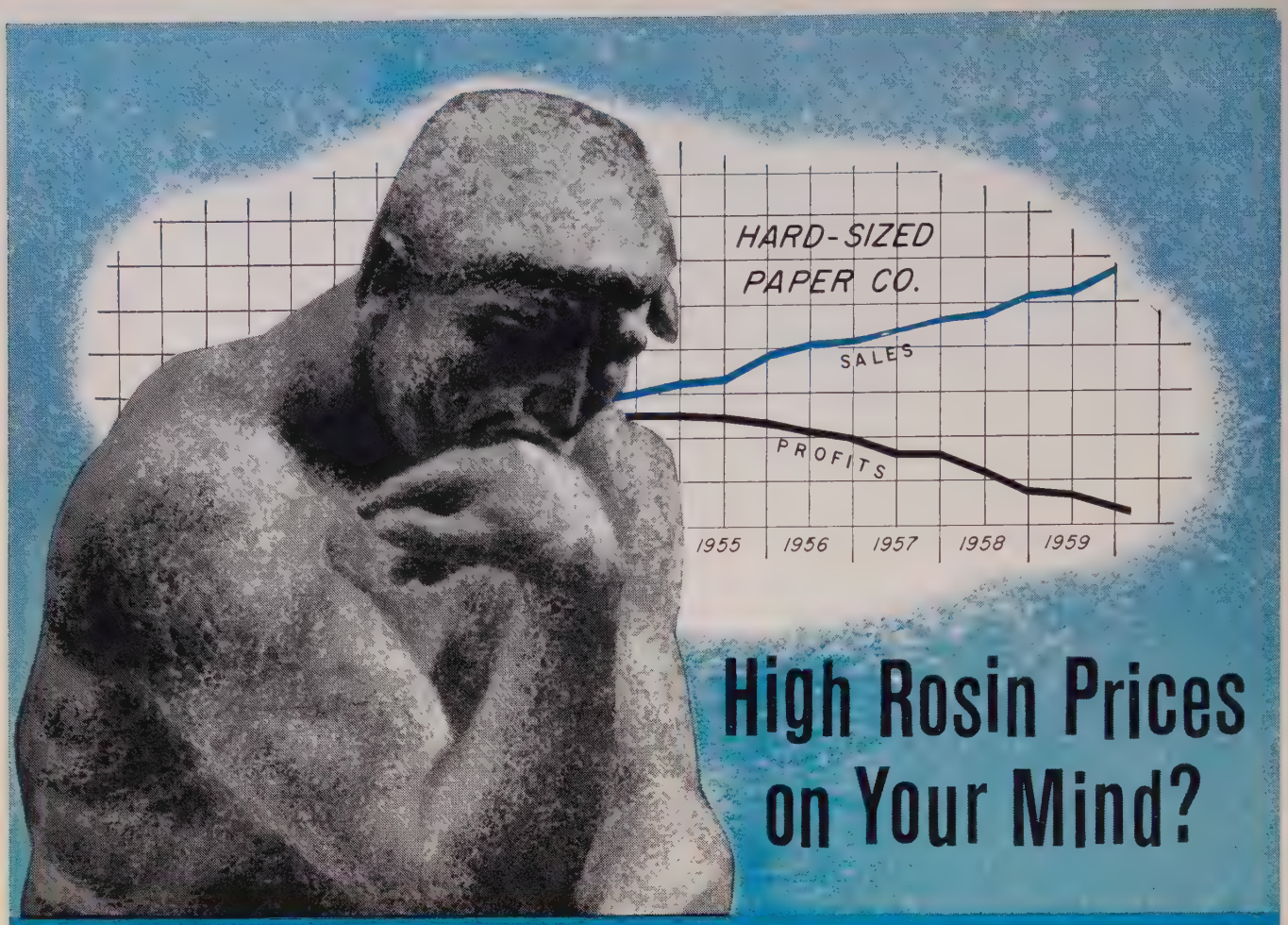
Graver

ONE OF THE UNION TANK CAR COMPANIES

Today, all of Weyerhaeuser's modern mills stand ready to satisfy your needs for bleached sulphite and bleached kraft.

Weyerhaeuser Company

Pulp and Paperboard Division



High Rosin Prices on Your Mind?

RCI WETstrez P-685 Cuts Rosin Size Requirements!

● Now, more than ever, this modified acid-curing urea-formaldehyde resin affords money-saving advantages. *WETstrez P-685 has the unique ability to reduce by ⅓ to ½ the amount of rosin needed in hard-sized paper.*

Yet paper quality is maintained, or even upgraded!

When added to starch at the size press, WETstrez P-685 improves the dimensional stability and increases the wax pick of the sheet. Higher Mullen and tensile strengths are obtained.

This improved technique allows the papermaker to decrease the amount of fortified or rosin size in the beater. This frees the stock, and faster drainage on the wire occurs. A better formed sheet at higher machine speeds is obtained. *And with no unusual broke recovery problem.*

For complete technical data and information on the general technique for incorporating WETstrez P-685 into your paper manufacturing, write Reichhold for *Technical Bulletin P-12.*

Creative Chemistry . . .
Your Partner in Progress

RCI

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Synthetic Resins • Chemical Colors • Industrial Adhesives • Phenol
Hydrochloric Acid • Formaldehyde • Phthalic Anhydride
Maleic Anhydride • Ortho-Phenylphenol • Sodium Sulfite
Pentaerythritol • Pentachlorophenol • Sodium Pentachlorophenate
Sulfuric Acid • Methanol

REICHHOLD CHEMICALS, INC.,
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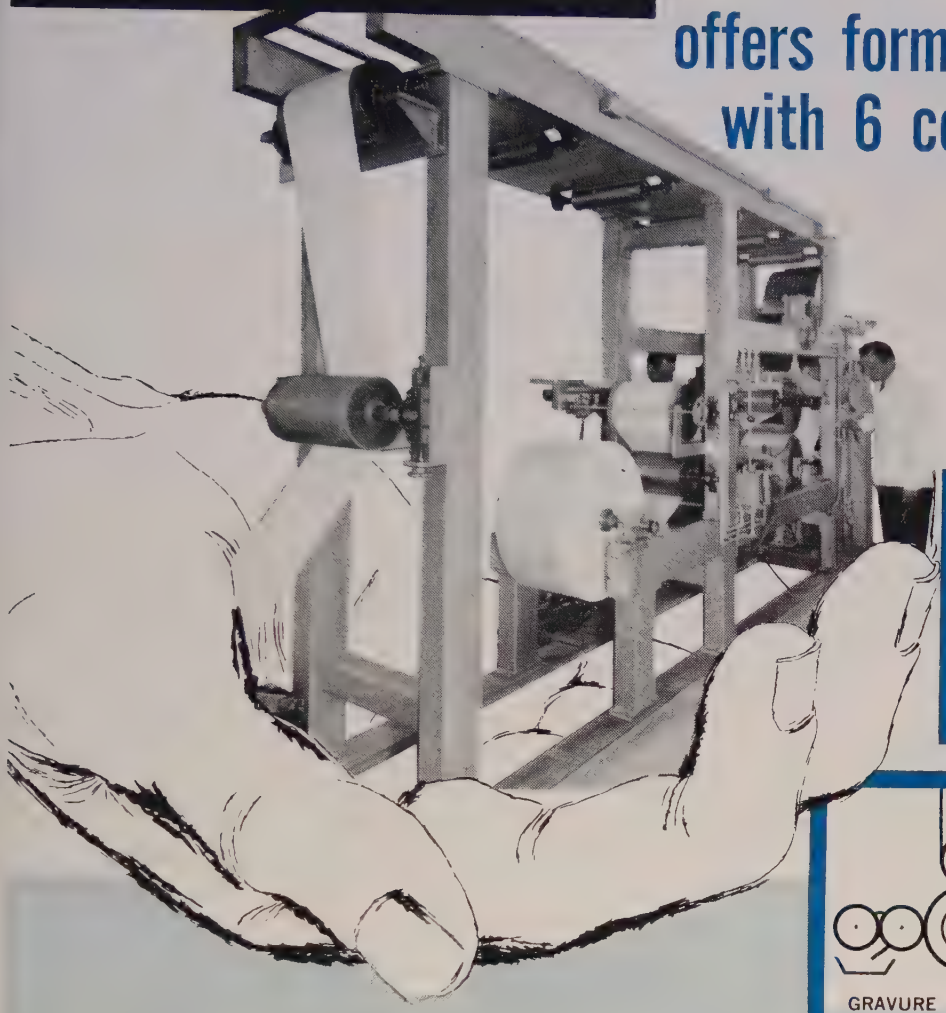

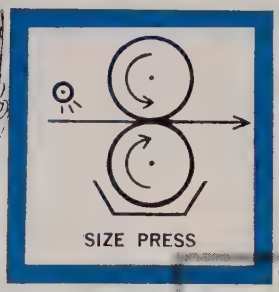

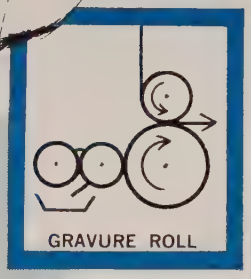

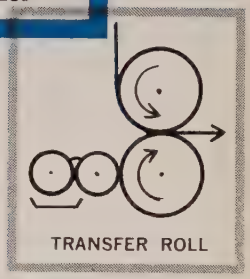

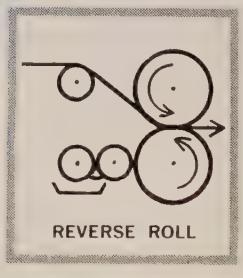

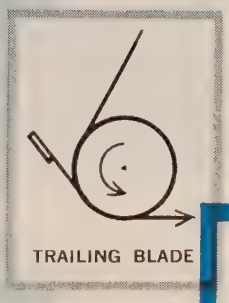

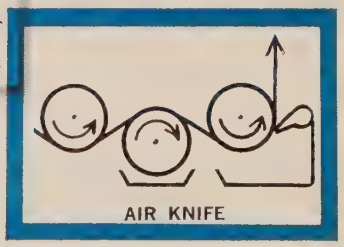

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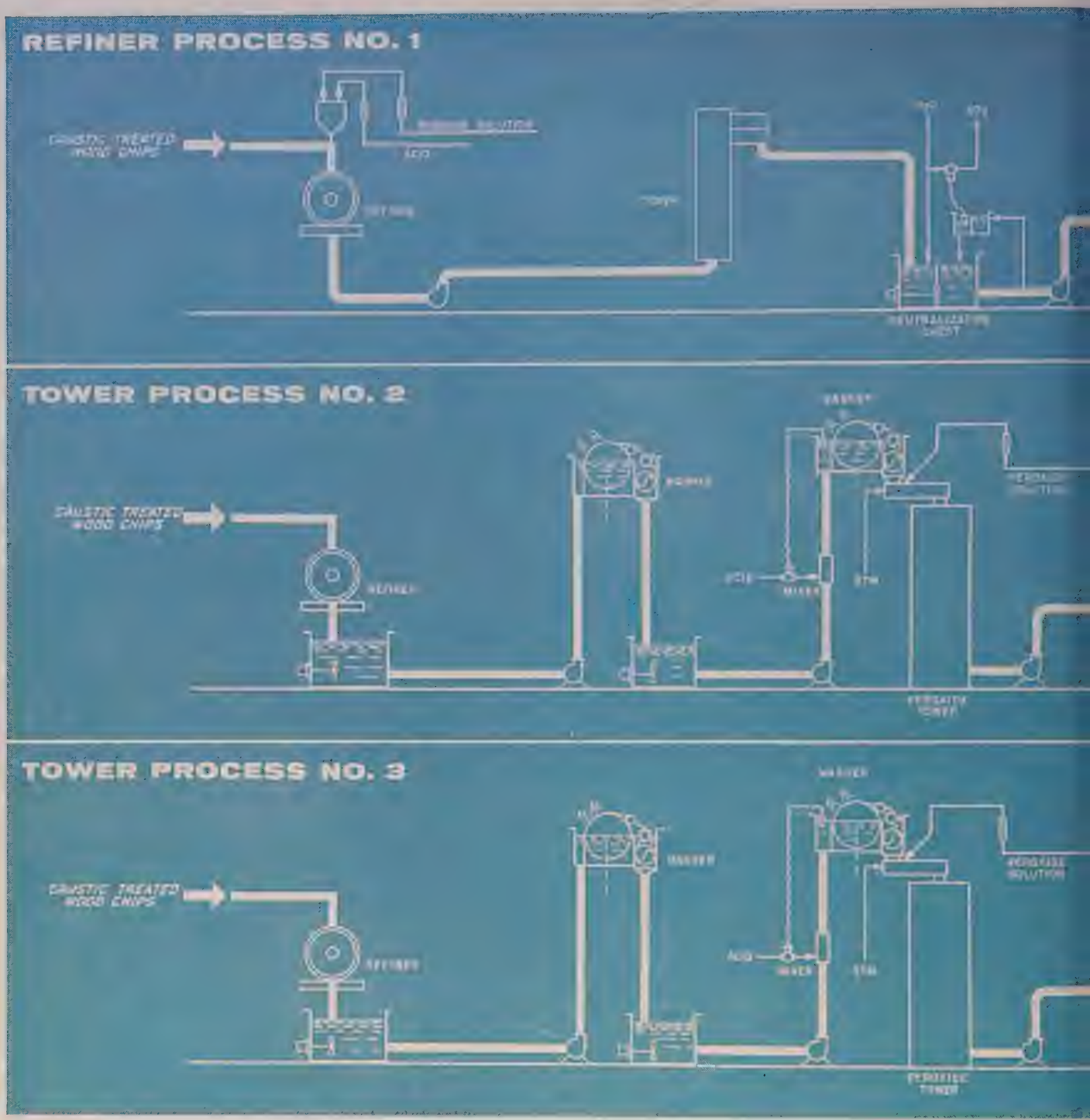

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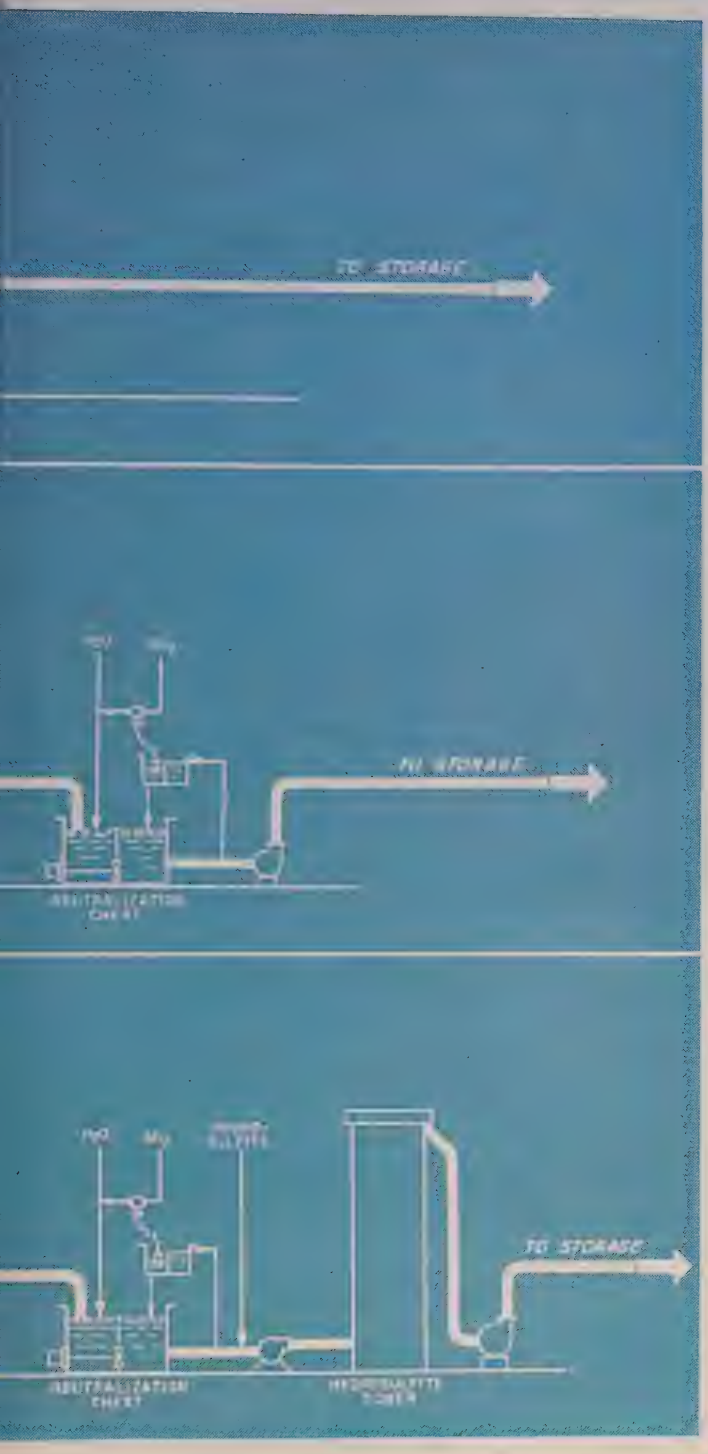

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60 brightness. In process No. 1 at left, caustic-treated wood chips enter refiner and are bleached with "Albone" hydrogen peroxide and acid*. The use of acid controls the alkalinity of the bleaching reaction and assures maximum response from the hydrogen peroxide. Sulfur dioxide (SO_2) then neutralizes the bleached pulp and stabilizes the brightness obtained in the refiner. **Du Pont Patent Pending.*

65 to 75 brightness. In process No. 2 at left, pulp is refined, washed to remove caustic solubles, acidified with sulfuric acid to remove acid solubles, washed, and bleached in a conventional peroxide tower to desired brightness in the 65 to 75 range.

70 to 80 brightness. In process No. 3 at left, pulp goes through the same steps as in process No. 2. Then pulp is neutralized, and bleaching is completed in a hydrosulfite tower for maximum brightness in the 70 to 80 range.

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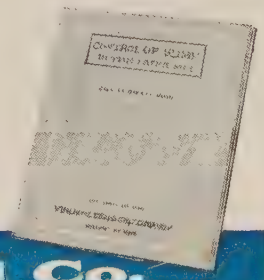

* *Test results available on request.*

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ideas and news

One-man maintenance for new vertical pump: This redesigned A-C pump gives quick access to internal parts. One mechanic can remove entire rotating element without need of an electrician to disconnect the motors or a pipe fitter to break piping. In addition, vertical design takes 25% less floor space than horizontal units.

No bake-out for wet motor: This Super-Seal motor, installed in a low-lying work room of a Connecticut paper mill, has repeatedly been under 5 to 6 feet of water. When the flood water recedes, the motor goes back into service without costly, time-consuming "bake-out." Poxeal and Silco-Flex insulations, used in Super-Seal motors, are impervious to moisture, dust, dirt, oils and most acids and alkalies.

So low, two fit where one used to go: SpaceMaker control center is the first completely new 2- to 5-kv motor controller in more than a decade. Its compact, two-high design cuts floor space in half. New flame-retardent, track-resistant Super Pyro-Shield insulation reduces controller size and weight, adds to reliability. Full drawout construction makes this the safest, most accessible controller available. The door cannot be opened unless the contactor is disconnected with all "live" connections isolated. One man can roll the contactor carriage out of the enclosure for obstruction-free inspection and maintenance. Contacts are completely accessible.

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	APPLICATION: Beater	Calender	Coating	CLASS: Basic	Acid	Direct	Pigment
YELLOW							
Auramine	•	•		•			
Brilliant Pure Yellow	•				•		
Chinoline Yellow	•	•	•		•		
Chrome Yellow	•		•				•
Chrysophenine	•					•	
Direct Yellows	•		•			•	
Fast Light Yellow		•	•		•		
Fastusol® Yellows	•		•			•	
Hansa® Yellow	•		•				•
Metanil Yellow	•	•			•		
Oxide Yellow	•		•				•
Paper Yellow	•					•	
Permagen® Yellow	•		•				•
Stilbene Yellows	•					•	
Tartrazine		•			•		
ORANGE							
Acid Orange	•	•	•		•		
Benzo Fast Oranges	•		•			•	
Chrysoidines	•			•			
Direct Fast Oranges	•		•			•	
Fast Light Orange		•			•		
Fastusol Oranges	•		•			•	
Orange	•	•	•		•		
Permanent Orange	•		•				•
Paper Orange	•					•	
BROWN							
Benzo Brown	•					•	
Bismarck Browns	•		•	•			
Fastusol Browns	•		•			•	
RED							
Benzo Bordeaux	•					•	
Benzo Fast Scarlets	•		•			•	
Benzo Rhoduline® Red	•		•			•	
Brilliant Croceine	•	•	•		•		
Direct Pink	•					•	
Direct Reds	•					•	
Fast Red	•				•		
Fastusol Pink	•		•			•	
Fastusol Reds	•		•			•	
Fastusol Scarlet	•		•			•	
Magenta	•	•	•	•			
Oxide Red	•		•				•
Paper Red	•				•		
Paper Scarlets	•					•	
Permagen Red	•		•				•
Permanent Carmine	•		•				•
Rhodamines	•	•	•	•			
Safranine	•	•	•	•			
Solar® Pink	•		•				•
Solcarbo® Pink	•		•			•	

	APPLICATION: Beater	Calender	Coating	CLASS: Basic	Acid	Direct	Pigment
VIOLET							
Brilliant Benzo Violet	•					•	
Crystal Violet	•	•		•			
Ethyl Violet	•	•		•			
Fastusol Violets	•					•	
Formyl Violet	•	•			•		
Methyl Violet	•	•		•			
Solar Coating Violet			•				•
Solar Violet	•		•				•
BLUE							
Benzo Azurine	•		•			•	
Benzo Blues	•		•			•	
Benzo Sky Blue	•		•			•	
Brilliant Benzo Blue	•		•			•	
Brilliant Wool Blue		•			•		
Fast Bond® Blues	•				•		
Fastusol Blue	•		•			•	
Fastusol Turquoise Blue	•		•			•	
Heliogen® Blues	•		•				•
Methylene Blue	•	•	•	•			
Neptune® Blues		•	•		•		
Paper Pure Blue	•	•	•	•			
Rhoduline Blues	•	•		•			
Solar Blues	•		•				•
Solar Coating Blue			•				•
Solcarbo Blues	•		•			•	
Soluble Blues	•				•		•
Victoria Blue	•	•	•	•			
Victoria Pure Blue	•	•	•	•			
GREEN							
Benzo Greens	•					•	
Brilliant Green	•	•	•	•			
Fast Bond Green	•				•		
Fastusol Greens	•					•	
Guinea Green	•	•	•		•		
Heliogen Greens	•		•				•
Heliogen Viridines	•		•				•
Naphthol Green		•	•		•		
Neptune Green	•	•	•		•		
Pigment Green	•		•				•
Solar Green	•		•				•
Victoria Green	•	•	•	•			
BLACK							
Acid Black		•			•		
Basic Black	•	•		•			
Diamine Black	•		•			•	
Diazo Black	•		•			•	
Direct Deep Black	•		•			•	
Fastusol Greys	•		•			•	
Naphthylamine Black	•	•	•		•		
Nigrosines	•		•			•	
Permanent Black	•		•				•

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An Evaluation of Certain Laboratory Pulping Methods

EDWARD F. THODE, JOHN R. PECKHAM, and EDWARD J. DALESKI

Two pieces of pulping equipment were recently acquired by the Engineering and Technology Section of The Institute of Paper Chemistry. One features the use of a number of *ca.* 1/2-liter capacity, stainless steel vessels which are heated by tumbling end over end in an oil bath. It is referred to as a "multi-unit" digester. The other is a two-vessel system in which cooking liquor is preheated before its introduction to the 14-liter autoclave which holds the chip charge. This latter device is known as the "isothermal" digester. The performances of the two new items of equipment were evaluated for alkaline pulping in comparison with conventional, vertical, stationary digesters (VSD) of 44-liter capacity. Comparison of the multi-unit system with the VSD showed that the small digesters removed both lignin and carbohydrate at a higher rate than did the standard unit, at various values of water ratio and of active alkali. Also, at the very high water ratio and negligible impregnation time required by the isothermal digester, the small, tumbling digesters removed more lignin and carbohydrate than the specialized isothermal unit. However, when all three systems were compared by adjusting cooking times using the *H* factor, both isothermal and VSD were more efficient in delignification than the multi-unit device. The multi-unit showed the lowest yield. Although replication of results among the three devices is not fully realizable, the data so far obtained do not show sufficiently large differences to cast doubt on the general trends of any specific pulping study. The use of such special-purpose devices for efficient laboratory studies in alkaline pulping is therefore considered expedient and technically sound.

Laboratory pulping studies are customarily carried out in pressure vessels which are miniature replicas of commercial digesters. As a general rule, they vary in volume from 1 to 2 cu. ft., construction material is often stainless steel, and heating is usually carried out by circulating the liquid contents through a steam heat exchanger. Many installations of these vessels are fitted with electronic devices which give the operator very good control over the cooking conditions.

From time to time, because of the need to perform experiments outside the limitations of the usual digesting system, a laboratory will design pulping equipment for a specific use. Many times such a device must be operated under conditions which differ drastically from the conventional. Again, because of the scarcity of raw materials or a need for a multiplicity of samples, very small-scale units have been fabricated so that a number of samples can be processed at the same time.

The Pulping and Papermaking laboratory of the Engineering and Technology Section, The Institute of Paper Chemistry, has acquired equipment in both categories. One device comprises seven small bombs of about 1/2-liter capacity which can be processed simultaneously. It is referred to as a "multi-unit" digester. Another is a so-called "isothermal" digester, so arranged that heated liquor is introduced to the chip charge in such a manner that the time to maximum temperature is negligible. Each is potentially a useful supplement to the array of vertical, stationary digesters which are operated in a conventional manner in this laboratory. However, before data from these could be fully utilized, a comparison study was essential. This paper is a report of a study which used the operation of a 1 1/2 cu. ft. stationary, vertical digester as a reference point.

Edward F. Thode, John R. Peckham, and Edward J. Daleski, Engineering and Technology Section, The Institute of Paper Chemistry, Appleton, Wis.

DESIGN OF EXPERIMENT

It was the purpose of the investigation to evaluate the utility of the two new pieces of digesting equipment in terms which would be meaningful to technical men familiar with conventional equipment. The first phase involved the use of the multi-unit equipment; a kraft pulping study carried out some time ago in a stationary, vertical digester was used as the basis of comparison. The primary variables were water-to-wood ratio and active alkali applied. The chips employed in the recent work were from a lot of sprucewood similar to that used in the earlier work. All cooking conditions except relief of false pressure were duplicated in the multi-unit equipment.

In the second phase, the multi-unit and isothermal equipment were compared, also using spruce chips and the kraft process. The conditions were dictated by the limitations of the isothermal unit; conditions in the multi-unit vessels paralleled these as closely as possible.

The third phase used all three types of digesters, and again the conditions were those necessary for the operation of the isothermal device. Since the time to reach maximum temperature was necessarily variable in the three devices, the "*H* factor" recommended by Vroom (*3*) was used to provide equivalent cooking time for the several vessels.

Pulps were compared with one another by measuring the yield, KAPPA number, and for some tests, viscosity of the product. The methods used are those listed in Table I.

DESCRIPTION OF EQUIPMENT

Vertical, Stationary Digester

The ordinary stationary digester of 1- to 2-cu. ft. capacity has, over a period of years, been accepted as a tool for laboratory study of the variables in the several pulping processes. It has been shown that the results obtained could, by the application of the experimentally determined factors, be correlated with the operation of industrial equipment. The one which was used in this investigation has a capacity of about 1 1/2 cu. ft. It is of stainless steel construction and is fitted with a steam heat exchanger and a forced liquor circulation system. Temperature is measured both with a calibrated thermometer inserted in an oil-filled well in the

Table I. Methods Used in Pulping Study

KAPPA number:	Method of Tasman and Berzins (*2*)
Permanganate no.:	TAPPI Standard T 214 m-50
C.E.D. viscosity:	TAPPI Standard T 230 sm-50
Lignin (direct determination):	TAPPI Standard T 222 m-54
Lignin (estimation):	Data of Tasman and Berzins (*2*)

digester head and by means of a Bristol recording pyrometer operating from an iron-constantan thermocouple located in the liquor circulating line.

In the cooks for phase 1, the chips were charged to the digester and voided at the end of the cooking schedule by blowing into a water-padded blow tank which has a perforated, false bottom. Washing was done in this tank by filling it with water and emptying it three times. For phase 3, the chips were loaded in a stainless steel, removable liner having a perforated cone bottom, similar to that in the digester itself. At the end of the cooking cycle, the spent liquor was expelled through the blow line. Immediately afterward, a water connection in the bottom of the digester was opened and the chips were flooded with cold water. When the cover was removed, the metal basket with its content of cooked chips was removed and the rough pulp was transferred to another vessel for primary defibering under a Williams stirrer. The pulp was then placed in a muslin-covered washbox where the residual chemical was flushed away.

In all cases, screening was done on a small Valley flat screen fitted with a 0.010-in. cut plate. The plate was then dewatered, with care being taken to preserve fines, and the yield was determined by oven drying representative samples of the dewatered and crumbed pulp.

Multi-Unit Digester

Figure 1 shows the multi-unit digester. The oil bath is made of 12-gage black iron. The over-all dimensions are $26\frac{1}{2}$ by 18 by 17 in., and the $\frac{3}{16}$ by $1\frac{1}{2}$-in. angle iron framework brings the top of the tank to a 30-in. height. A half cylinder hood encloses the outside. Eleven 500-watt heating units are attached to the bottom and four similar units are fastened to each of the two longer sides. The heaters are supplied from a 3-phase, 250-volt a.c. line and are balanced as closely as possible across each phase. The effective total load on the bottom is 10 kw. and on each side is 7.5 kw. This arrangement provides a maximum of 120°C. temperature rise per hour for the bath. The whole tank, less the hood, is insulated with 2 in. of Johns-Manville 85% magnesia block and is covered by $\frac{1}{4}$-in. transite sheets. The side heating units are directly connected to the electrical supply and are manually operated. At cooking temperature, the bottom units are controlled through a Minneapolis-Honeywell Pulse Pyr-O-Vane, actuated by a set of iron-constantan thermocouples fastened in the tank below the oil bath. The system is controlled manually through a Variac control on the bottom units during the time to temperature. The oil used is Texaco Regal Oil K, code 838; it is reasonably free of odor at cooking temperatures.

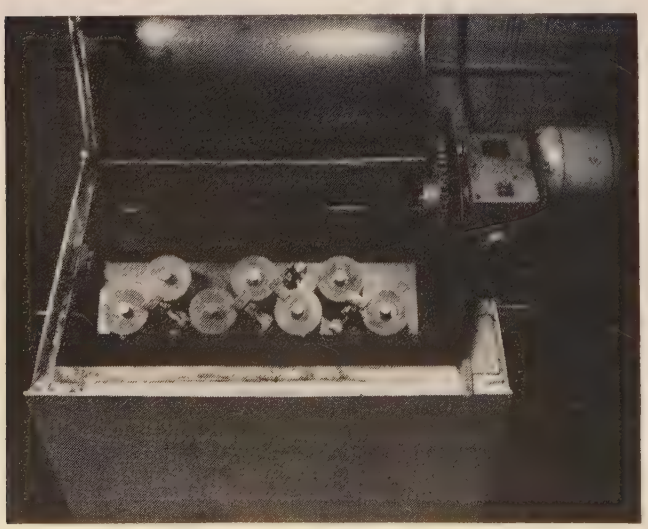

Fig. 1. Multi-unit digester system

Fig. 2. Individual unit used on multi-unit system

The vessels, one of which is shown in Fig. 2, are fabricated from standard 2-in. 316 stainless steel pipe. Each is $9\frac{1}{2}$ in. long and has a volume of 475 ml. Gaskets are cut from $\frac{1}{4}$-in. thick sheet Teflon. The lid closures, held firmly in place by a cap screw threaded through the pipe cap which tops the assembly, have given good service. The unit which holds the seven bombs rotates in the bath at 3 r.p.m. It is suspended with the center of rotation $10\frac{1}{2}$ in. from the bottom of the tank and is driven, through a chain and sprocket linkage, by a Bodene gear-head motor with an output speed of 2 r.p.m. The bombs are locked into position with De-Sta-Co clamps.

In this study, each vessel was charged with chips weighed to the nearest 0.01 g. Liquor and water were added to provide the proper chemical level and concentration, and the caps were secured. Standard practice was to preheat the bath to 70°C. before immersing the cooking units in the interests of reaching maximum temperature with a more easily controlled heat input. When simulating the action of the isothermal digester, the vessels were immersed when the bath temperature coincided with the maximum cooking temperature desired. At the end of the cooking period, the rotating device was halted and the vessels were removed and immediately quenched in a large container supplied to overflowing with cold tap water. After 5 min. in this bath, they were opened and the contents were removed to a muslin-covered washbox. Here the cooked chips were broken up by hand manipulation while being rinsed with a stream of warm water. The pulp was screened on the previously described Valley flat screen. In phase 1, all samples for testing

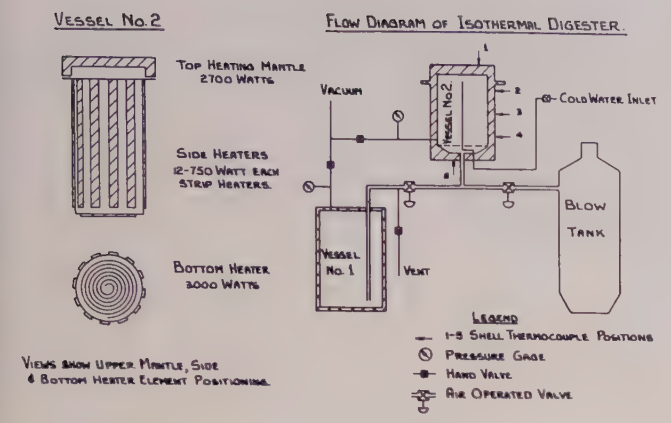

Fig. 3. Isothermal digester

were removed as aliquots from a known dilution of the stock in filtered tap water. In phases 2 and 3, the entire yield of washed and hand-defibered pulp was decanted on a tared filter paper and the wet pad was air-dried to a constant weight in a forced-circulation, filtered air cabinet. Moisture content of the air-dried stock was determined. Considerably better replication of yield and KAPPA number data was obtained through the latter procedure.

Isothermal Digester

The isothermal digester was designed and built by Walters and May for use in a study of the kinetics of the sodium sulfite delignification of aspen sapwood (*4*). Figure 3 shows a diagram of the equipment.

Two stainless steel vessels, connected by a heavy-duty $^3/_4$-in. stainless steel pipe, are separated by an air-operated quick-opening valve. The so-called "prechamber" is an electrically heated, high-pressure vessel fitted with a stirrer. Power input is controlled by a rheostat. The second vessel is designed to resist pressures in excess of 1000 p.s.i. and has connections for vacuum and cold water lines. A quick-opening air-operated valve is placed in a pipe line leading to a cyclone separator. When opened, the cooling liquor can be voided rapidly. The chips are charged in a specially prepared basket which insulates them from the heated walls and bottom of the digester. The basket also has a central core which fits over a vertical, perforated pipe so that the cooked chips can be cooled by a water shower before the digester cover is removed. Temperature measurements are recorded on a Minneapolis-Honeywell high-speed potentiometer. Thermocouples are located in the liquor in the preheater, in the digester walls, and in the digester contents.

In practice, before the cook is started, the prechamber is prepared by repeatedly purging it with nitrogen, successively pressurizing and evacuating it until all signs of moisture in the gas disappear. The prechamber is charged by evacuating the closed system and opening an intake line immersed in the previously prepared liquor. The temperature of the liquor is elevated by means of the electrical resistance elements arranged around the outside of the prechamber.

While the liquor is heating, chips are charged to the specially designed basket and placed in the digester, which is then tightly capped. A vacuum pump is started, drawing approximately 30 in. of vacuum on the vessel. This is an effective device for preventing heat transfer from the digester walls to the chips and also removes air from the interior of the chips.

After the liquor is preheated to several degrees centigrade higher than the maximum intended for the cook and the shell of the digester has reached the predetermined value, the cooking reaction is started by shutting off the vacuum line and opening the valve in the line joining the two vessels. The transfer line is left open until the cook is completed and the liquor is removed to the cyclone blow tank. At this point, the cooked chips are showered with cold water to lower the temperature even further.

Defibering, washing, screening, and yield-determination techniques parallel those described for the vertical, stationary digester.

Table II. Comparison of Pulping Characteristics of Two Samples of Sprucewood

Cook	6	C14	7	C16
Wood sample	New	Old	New	Old
Active alkali, % as NaOH	20.5	20.5	27.45	27.45
Unscreened yield, %	51.0	49.8	46.5	45.6
Permanganate no. (40-cc. basis)	24.2	24.0	15.2	14.4
KAPPA no.	33.1	...	18.5	...
C.E.D. viscosity, cp.	...	114.0	...	46.4
Lignin, %	...	4.6	...	2.4
Constant conditions:				
Water ratio, cc./g.				6.0
Sulfidity, %				28.0
Maximum temperature, °C.				173
Time to 134°C., hr.				0.5
Time at 134°C., hr.				1.0
Time from 134 to 173°C., hr.				0.5
Time at 173°C., hr.				2.0
Blowdown to 80 p.s.i., hr.				0.25

EXPERIMENTAL

A portion of a pulping study made in the vertical, stationary digester on commercially prepared spruce chips was reproduced in the multi-unit device. It was recognized that some variables would not be reconciled, but if gross differences in pulping action existed, this study would be expected to point them up. The wood used was obtained from the Interlake Division mill of the Consolidated Water Power & Paper Co. and was obtained in the form of peeled bolts which were reduced to chips in a 48-in. Carthage chipper. Nominal chip size was $^3/_4$ in. The chips were screened to remove those which would pass a 4-mesh screen and large knots and silvers were discarded. The wood was air dried to *ca.* 90% moisture-free content. Two digestions were made in the vertical, stationary digester to compare the ease of pulping the recent and the original wood samples. Two different levels of active alkali at 28% sulfidity were chosen. The data concerning the pulps appear in Table II. It appeared that the new sample of wood could be expected to cook to a given level of delignification in very nearly the same time as the old, and at that level of cooking would yield about 1% more pulp, based on wood charged to the digester.

With the two wood supplies related to each other, the multi-unit vessels were charged with the new wood and processed under the conditions previously utilized in the stationary, vertical digester. Active alkali applications of 18, 19, 20, 22, 24, 26, and 28% (all as sodium hydroxide) were used. Cook MU1 utilized 4.5 to 1 water ratio; in cook MU2, the ratio was increased to 6.0 to 1, and for cook MU5, the ratio was 3.0 to 1. The data concerning the digestions are shown in Table III.

Table III. Multi-Unit Pulping Study—Variable Water Ratio

Vessel →	*A*	*B*	*C*	*D*	*E*	*F*	*G*
Cook MU2 (water ratio 6.0 cc./g.[a])							
Active alkali as NaOH, %	18	19	20	22	24	26	28
Yield, %[a]	50.7	48.8	48.2	45.9	44.8	40.0	39.8
KAPPA no.	55.9	43.8	36.8	27.5	21.8	16.4	14.1
Lignin, %[b]	7.1	5.6	4.7	3.6	2.9	2.0	1.7
Z-value[c]	0.076	0.059	0.049	0.037	0.030	0.020	0.017
C.E.D. viscosity, cp.	...	29.1	...	30.7	...	17.8	15.2
Cook MU1 (water ratio 4.5 cc./g.[a])							
Active alkali as NaOH, %	18	19	20	22	24	26	28
Yield, %[a]	49.4	49.5	47.0	45.0	43.2	43.2	42.4
KAPPA no.	40.7	33.1	27.1	20.4	16.0	14.3	11.3
Lignin, %[b]	5.3	4.3	3.5	2.7	1.9	1.7	1.3
Z-value[c]	0.056	0.045	0.036	0.028	0.019	0.017	0.013
C.E.D. viscosity, cp.	...	34.4	...	...	17.3	13.9	11.2
Cook MU5 (water ratio 3.0 cc./g.[a])							
Active alkali as NaOH, %[a]	18	19	20	22	24	26	28
Yield, %[a]	46.0	46.3	44.1	43.2	41.3	40.3	39.7
KAPPA no.	31.1	26.5	21.4	17.9	14.8	11.7	10.7
Lignin, %[b]	4.0	3.3	2.7	2.2	1.7	1.3	1.2
Z-value[c]	0.042	0.034	0.028	0.022	0.017	0.013	0.012

Constant conditions:			
Chip charge, g.[a]	50.0	Time from 134 to 173°C., min.	60
Max. temp. °C.	173	Time at 173°C., min.	120
Time to 134°C., min.	30	Sulfidity, %	28
Time at 134°C., min.	60		

[a] Basis moisture-free wood.
[b] Derived from KAPPA no.
[c] See reference (*1*).

In phase 2 of the study, the multi-unit digesting system was compared with the isothermal. The conditions used, shown in Table IV, featured the abnormally high liquor-to-wood ratio demanded by the isothermal equipment. Isothermal cooks IT1 and IT2 were duplicates, made with a kraft liquor of 25% sulfidity and held at a maximum temperature of 171°C. for 85 min. The yields were nearly identical, but the KAPPA numbers were 3.7 points apart at 33.8 and 30.1. Cook IT3 paralleled the two previous cooks but utilized a liquor of 18.5% sulfidity. The yield of pulp was higher than those found in cooks 1 and 2, but the KAPPA number was only 30.1.

In multi-unit cook MU6, several effects were investigated, including the use of the isothermal schedule. One vessel, MU6D, was immersed in the oil which had been brought to maximum temperature in a set time schedule to accommodate other experiments. It was held in the bath for 88.5 min. Cook MU7 was performed in the same manner and MU7D duplicates MU6D in all respects. Agreement in KAPPA number and yield are considered good, but both are lower than obtained in the duplicate isothermal experiments. Cook MU8, which paralleled cooks MU6 and 7 in rate of temperature increase and maximum bath temperature, contained two vessels with identical wood and chemical charges. Vessels C and E were immersed when the bath was at maximum temperature. Vessel E was removed after 85 min. of cooking, and C after 88.5 min. In this instance, replication was not particularly good, with the data at 85 min. agreeing with the 88.5-min. cooks made previously. The cook allowed to react for 88.5 min. had reduced yield and KAPPA number.

Isothermal cook 3 and two vessels from multi-unit cook 8 were used to introduce the variable of kraft liquor sulfidity. Other conditions were maintained constant, but cook IT3 was performed at 18.5% sulfidity as were MU8C and MU8D. Of the two multi-unit cooks, D was removed after 85 min. in the bath, C after 88.5 min. The KAPPA number of cook IT3 (18.5% sulfidity) agreed quite well with those of the pulps made at 25% sulfidity but a higher yield was realized. The reverse was true when sulfidity level was studied in the two multi-unit cooks. Here yields were the same for the 18.5% sulfidity as for the 25% sulfidity pulps, but KAPPA numbers were higher.

The third phase of the study involved all three systems utilizing the high water ratio needed in the isothermal equipment. The conditions are shown in

Table IV. Comparison of Multi-Unit and Isothermal Digesting System

Digester	*Multi-unit*						*Isothermal*		
Cook	*MU6*	*MU7*	*MU8*	*MU8*	*MU8*	*MU8*	*1*	*2*	*3*
Vessel	*D*	*D*	*C*	*E*	*F*	*G*	..	...	..
Time at max. temp., min.	88.5	88.5	88.5	85	88.5	85	85	85	85
Sulfidity, %	25.0	25.0	25.0	25.0	18.5	18.5	25.0	25.0	18.5
Pulp yield, %[a]	45.4	45.2	44.5	45.6	44.8	44.8	48.1	48.2	50.2
KAPPA no.	25.0	26.0	23.2	25.6	26.8	29.2	33.8	30.1	30.1
Lignin, %[b]	3.2	3.4	3.0	3.3	3.5	3.8	4.4	3.9	3.9
Z-value[c]	0.033	0.035	0.031	0.034	0.036	0.040	0.046	0.041	0.041

Constant conditions, all cooks:	
Water ratio, cc./g.[a]	13.6
Liquor concentration, g./l. as Na_2O	40.0
Chip charge, g.[a]	
Multi-unit	31.9
Isothermal	1029
Max. temp., °C.	171

[a] Basis moisture-free wood.
[b] Derived from KAPPA number.
[c] See reference (*1*).

Table V. Comparison of Three Digesting Systems

Digester	Multi-unit						Vertical Stationary			Isothermal
Cook	MU7	MU6	MU8	MU8	MU9	MU9	VS3	VS4	VS5	IT4
Vessel	C	C	A	B	A	B	...	...	...	...
Sulfidity, %	25.0	25.0	25.0	18.5	25	18.5	25.0	25.0	18.5	25
Time to max. temp., min.	90	90	90	90	7	7	90	90	90	0
Time at max. temp., min.	40	40	40	40	47.5	47.5	40	40	40	49.2
Pulp yield, %	48.2	48.1	48.6	49.7	47.1	48.4	47.3	47.1	48.2	50.5
KAPPA no.	50.5	48.8	51.8	64.2	49.7	58.2	39.4	37.8	41.8	37.7
Lignin, %[a]	6.5	6.3	6.7	8.2	6.4	7.5	5.1	4.9	5.3	4.9
Z-value[b]	0.070	0.067	0.072	0.089	0.068	0.081	0.054	0.052	0.056	0.052
C.E.D. viscosity, cp.	...	29.1	...	...	...	...	...	33.5	...	24.0

Constant conditions:

Max. temp., °C	171
Water ratio, cc./g.[c]	13.6
Kraft liquor concn. as Na_2O, g./l.	40

[a] Derived from KAPPA no.
[b] See reference (*1*).
[c] Basis moisture-free wood.

Table V. The multi-unit and vertical, stationary digesters were directly compared in replicate MU cooks 6C, 7C, and 8A versus VS (vertical stationary) cooks 3 and 4, all at 25% sulfidity. The reproducibility is quite good in both pieces of equipment.

The single digestions at 18.5% sulfidity are MU8D and VS5. They indicated that both systems may be less efficient in the removal of lignin than they are at 25% sulfidity. The relative actions of the two pieces of equipment were the same at the reduced sulfidity as at 25%.

To bring the isothermal digester into the study, the *effective* cooking time was adjusted to equal that of the multi-unit and stationary-digester cooks by the application of the *H* factor. By this means, a time at temperature of 49.2 min. was chosen. The result was a pulp of high yield (50.5%) and low KAPPA number.

The *H* factor was used to establish fast cooking times in the multi-unit system in cooks MU9A and MU9B. In both cases, 7 min. were used to bring the digester to temperature after plunging it into the hot bath. Time at temperature was 47.5 min. The result was pulps apparently quite similar to those made with a schedule of 90 min. to temperature followed by 40 min. at temperature.

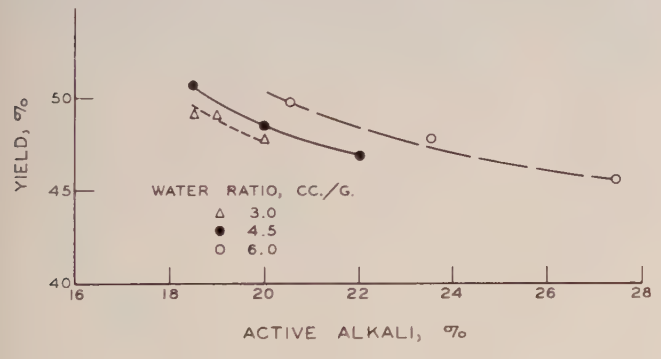

Fig. 4a. Relationship between pulp yield and active alkali charge for vertical stationary digester

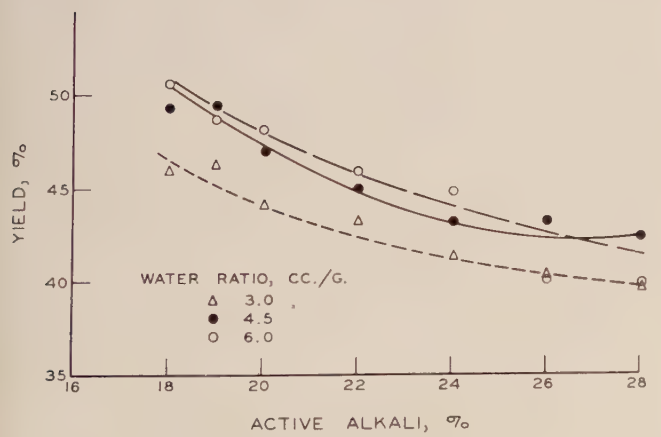

Fig. 4b. Relationship between pulp yield and active alkali charge for multi-unit digester

DISCUSSION OF RESULTS

In phase 1, the experiments made in the multi-unit system covered a greater number of individual treatment combinations than was the case with the vertical,

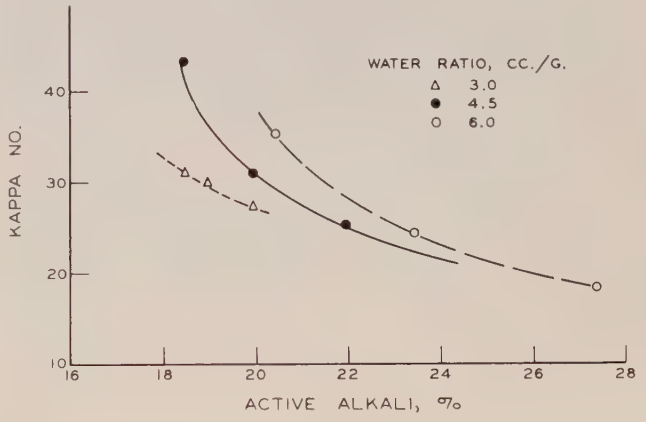

Fig. 5a. Relationship between pulp KAPPA No. and active alkali charge for vertical stationary digester

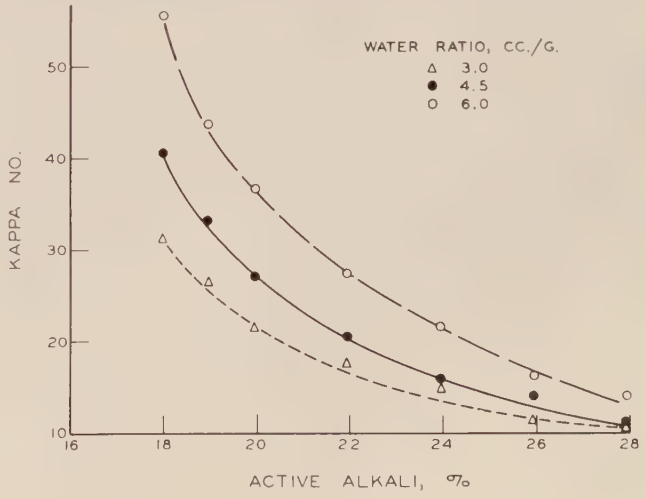

Fig. 5b. Relationship between pulp KAPPA No. and active alkali charge for multi-unit digester

Table VI. Properties of Pulps Made with 20% Active Alkali

Water ratio	*Digester*	*KAPPA no.*	*Yield, %*
3.0	Multi-unit	22.0	44.2
3.0	Vertical stationary	27.5	47.7
4.5	Multi-unit	27.2	47.3
4.5	Vertical stationary	31.2	48.5
6.0	Multi-unit	36.5	48.1
6.0	Vertical stationary[a]	37.8	50.3

[a] These data are extrapolated values.

stationary digester. The data concerning the cooks made at 3.0-, 4.5-, and 6.0-to-1 water ratios are shown in Table III. The lignin values were derived from the relationship between KAPPA number and Klason lignin given by Tasman and Berzins (*2*). Lignin values for the pulps made in the vertical, stationary digester were measured by the Klason technique.

Figure 4 shows the effect on yield of varying chemical concentration (as active alkali) in both the multi-unit and the stationary, vertical digesters. Figure 5 gives the parallel relationship between concentration and KAPPA number. From these two graphs it was possible to compare pulp properties at one level of chemical addition (Table VI) and at one level of delignification (Table VII). It will be noted that the KAPPA numbers were in fair agreement at one level of chemical addition, but that pulp yields were 1 to 2% higher in the vertical, stationary digester than they were in the small, tumbling units. The same yield differences are noted when the pulps are compared at a similar KAPPA number. It can be seen that the trends are not the same at all three levels of water-to-wood ratio, but the difference may stem from erratic yield data. Later data, obtained with improved technique, did not appear to result in the anomalies found occasionally in the phase 1 study.

The differences in yield in the two types of digesters was investigated by studying the lignin removal apparently accomplished. Table VIII shows that if the wood contained and assumed 27% lignin, the amount of the material removed was greater in the small, tumbling digesters in all cases. However, the difference is not great enough to account for the lower yield, which must be ascribed to the simultaneous removal of some nonligneous materials at a greater rate than occurs in the vertical, stationary digester. The conservation of the carbohydrate portions of the wood is shown in Fig. 6, where the *Z*-value derived for use in the Ross Diagram (*1*) is plotted against pulp yield. The lower portion in this graph, displayed by the data from the vertical stationary cooks, demonstrates that a consistently higher cellulose-to-lignin ratio is found at all yield levels. The greater scatter of the multi-unit points further demonstrated the need for precise methods of determining the yield in this equipment. The top line in Fig. 6 was obtained by plotting data presented by Tasman and Berzins spruce kraft pulps (*2*). It might be pointed out that the

Table VII. Pulp Yields at 30 KAPPA No.

Water ratio	*Digester*	*Pulp yield, %*
3.0	Multi-unit	46.1
3.0	Vertical stationary	49.0
4.5	Multi-unit	48.2
4.5	Vertical stationary	48.3
6.0	Multi-unit	46.5
6.0	Vertical stationary	48.8

Table VIII. Lignin Removal in the Vertical Stationary and Multi-unit Digesting Systems

Water ratio	*Digester*	*Lignin, %*	*Lignin removed, %*[a]
3.0	Multi-unit	2.9	95.3
3.0	Vertical stationary	3.6	93.6
4.5	Multi-unit	3.5	93.9
4.5	Vertical stationary	4.1	92.6
6.0	Multi-unit	4.7	91.6
6.0	Vertical stationary	4.9	90.9

[a] Basis an assumed 27% lignin in sprucewood.

cooking conditions used in the Canadian study were probably more rigorous than the very gentle 2-hr.-to-maximum temperature used in our phase 1 cooks.

The comparison of the multi-unit and isothermal systems carried out in phase 2 also pointed up differences in the rate of removal of wood constituents. The bombs of the multi-unit system were plunged into the oil bath, which was at the maximum temperature used for the cook. The bath suffered a momentary drop-off in temperature, which it recovered in $3^1/_2$ min. Time at temperature was calculated from that point. One vessel in cook MU8 was also taken out after 85 min. in the bath, which agreed with the reaction time maintained in the isothermal system. The work was repeated on a smaller scale with liquor of 18.5 instead of 25% sulfidity. Table IV shows that the average of three digestions at 88.5 min. in the multi-unit apparatus yielded 45% of pulp having a 24.7 KAPPA number. The average of two experiments in the isothermal digester showed 48.2% pulp of 31.9 KAPPA number. Changing liquor sulfidity seemed to slow the reactions, but the evidence was not clear-cut.

Table IX shows that lignin removal was more efficient in the multi-unit vessels than in the isothermal digester. The tendency for these small, tumbling

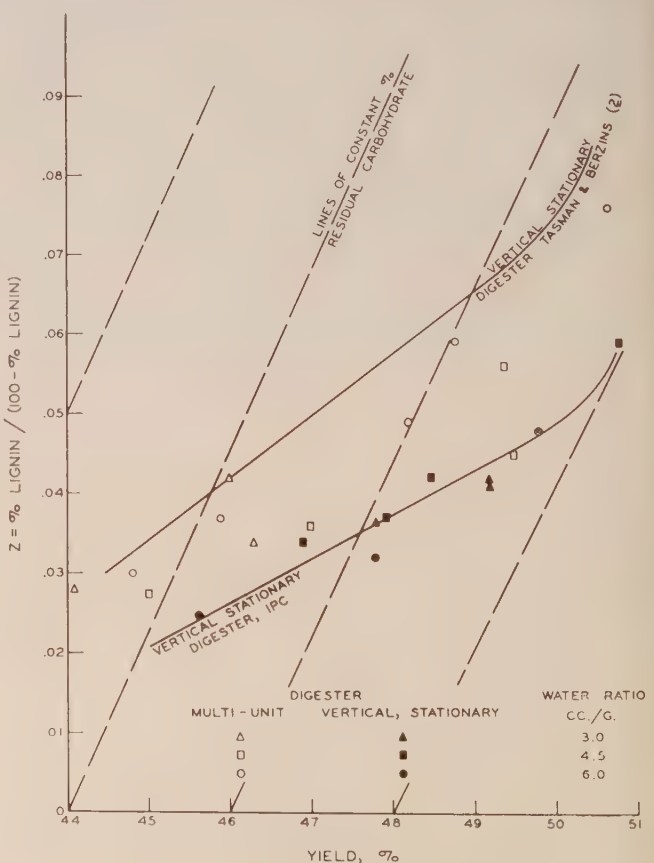

Fig. 6. Lignin–nonlignin ratio of pulps in phase 1

Table IX. Lignin Removal in the Isothermal and Multi-unit Digesting Systems

Digester system	*Sulfidity, %*	*Yield, %*	*KAPPA no.*	*Lignin, %*	*Lignin removed, %*[a]	*Z value*
Isothermal	25	48.2	32.0	4.1	92.7	0.043
Isothermal	18.5	50.2	30.1	3.9	92.8	0.041
Multi-unit	25	45.0	24.7	3.2	94.7	0.033
Multi-unit	18.5	44.8	26.8	3.5	94.2	0.036

[a] Basis an assumed 27% lignin in sprucewood.

bombs to remove materials other than lignin at an accelerated pace was further pointed up in this study. The isothermal system seemed to retain the nonligneous portion of the wood even more effectively than the vertical, stationary digester. The single points available were superimposed on a Ross diagram in Fig. 7 to show the degree of difference. The values for the pulps made with the liquor of 18.5% sulfidity are included. This figure has two lines of reference included. The top line is the relationship found by Tasman and Berzins (*2*) and the bottom line the results of the lignin-cellulose ratio of the vertical, stationary digester pulps from phase 1.

In phase 3, all three types of digesters were utilized. The high chemical-to-wood ratios which were necessitated by the adherence to the conditions required by the isothermal vessel required a relatively short time at a maximum temperature of 171°C. The application of the *H* factor to bring relative cooking times into agreement was quite effective, considering the gross difference in the way in which the elevation to maximum temperature was accomplished. The results can be seen in Table V. The multi-unit system proved to be the connecting link in the study since it could closely parallel the cooking schedule of the vertical, stationary

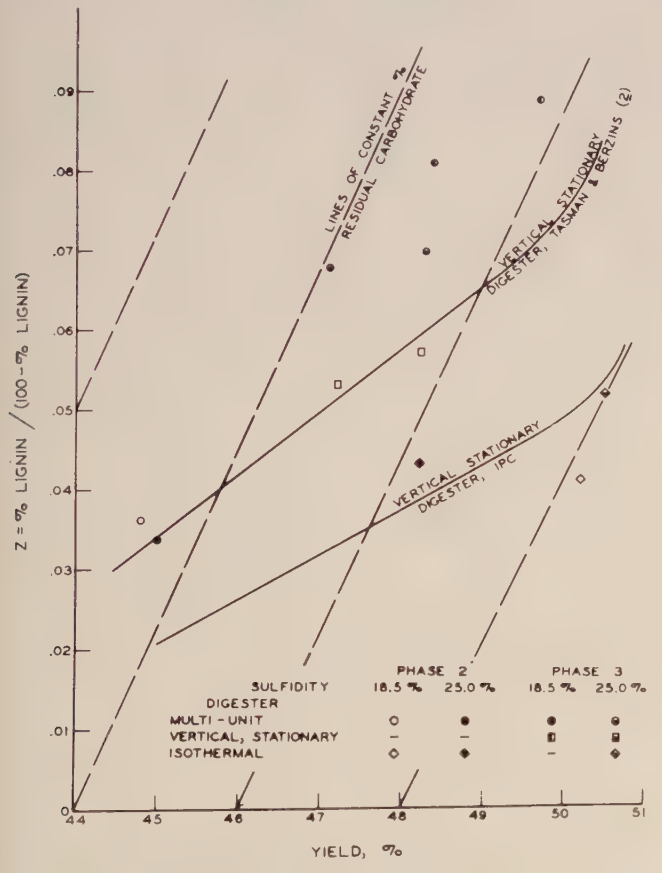

Fig. 7. Lignin–nonlignin ratio of pulps in phases 2 and 3

Table X. Lignin Removal in Three Digesting Systems

Digesting system	*Time schedule*[a]	*Sulfidity, %*	*Yield, %*	*KAPPA no.*	*Lignin %*[b]	*Lignin removed, %*[c]	*Z value*
Vertical stationary	A	25	47.2	38.6	5.0	91.3	0.053
Vertical stationary	A	18.5	48.2	41.8	5.4	90.7	0.057
Multi-unit	A	25	48.3	50.4	6.5	88.8	0.070
Multi-unit	B	25	47.1	49.7	6.4	88.8	0.068
Multi-unit	A	18.5	49.7	64.2	8.2	84.9	0.089
Multi-unit	B	18.5	48.4	58.2	7.5	86.6	0.081
Isothermal	C	25	50.5	37.7	4.9	90.8	0.052

[a] A = 90 min. to max. temp., 40 min. at max. temp.
B = 7 min. to max. temp., 47.5 min. at max. temp.
C = 0 min. to max. temp., 49.2 min. at max. temp.
[b] Derived from KAPPA no.
[c] Basis an assumed 27% lignin in sprucewood.

digester and also could approximate that of the isothermal digester. Triplicate cooks in the multi-unit device agreed quite well in yield and KAPPA number, using the vertical, stationary schedule. Bringing the contents to maximum temperature in a shorter time did not appear to change the product appreciably. Decreasing the sulfidity of the cooking liquor very definitely slowed the reaction in this experiment. Duplicate cooks in the vertical, stationary digester also agreed well. The tendency toward less delignification with a decrease in sulfidity was not as pronounced in this digester. The single cook in the isothermal digester was made at 25% sulfidity.

KAPPA numbers were very similar in the case of the vertical, stationary and isothermal devices at 25% sulfidity, indicating the validity of the use of the H factor in determining effective cooking times. The yields were quite high in the case of the isothermal digester, as had been indicated in phase 2.

Comparison of delignification rates is made in Table X. On the basis of lignin-removal efficiency, the vertical, stationary digester appeared to be slightly superior to the isothermal digester, and both were considerably better than the multi-unit vessels in this respect. This is the reverse of findings in the two previous studies where the multi-unit vessels, though yielding less pulp, were generally the most effective in removing lignin.

The low yield and high KAPPA number of the pulps in the small, tumbling vessels gave them a poor cellulose-lignin balance as compared with the pulps from the other two digesters. This was true with both of the cooking schedules used. The information concerning these cooks can also be found in Fig. 7.

CONCLUSIONS

The replication of values obtained in kraft pulping spruce chips was found to be of the same order of excellence for the multi-unit and isothermal digesters as for the vertical, stationary digester which provided the base-line data. All three pieces of equipment are equally subject to random error in operation, but the multi-unit is especially sensitive to errors in the yield determinations, primarily because of the very small sample size.

The multi-unit vessels appear to delignify spruce chips by the kraft process at a rate which slightly exceeds that which occurs in either the isothermal or vertical, stationary digester. There is some evidence, however, that this trend may be reversed by the appli-

cation of specialized conditions. Evidence was strong that more of the carbohydrate fraction of the wood was dissolved at a given degree of delignification in the multi-unit than in the vertical, stationary digester. The isothermal digester was, in turn, more efficient in the preservation of the carbohydrate constituents of the wood than was the vertical stationary digester.

The carbohydrate-lignin ratio of the products of the kraft digestions indicated the extent of the difference in the relative rates of dissolution of the various wood constituents when pulped in the three kinds of digesters. Furthermore, inclusion of published data concerning a kraft pulping experiment carried out in a vertical, stationary digester with sprucewood points out that the differences between the reaction taking place in *two vessels* of *similar construction* may be as great as those between the dissimilar devices studied here.

The indications are that most of the pulping variables of interest may be explored in either of the two special-purpose digesters with good assurance that the trends found can be validated by replication of the testing in the ordinary, vertical, stationary digester.

Further work seems in order with a view to isolating the physicochemical conditions which favor the conservation of carbohydrate materials and the solution of lignin. Strength tests would be required to determine whether the additional carbohydrate fraction retained by certain digester arrangements is beneficial to the papermaking properties of the pulp so produced.

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Isolation of Galactoglucomannans from the Wood of Gymnosperms

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A galactoglucomannan has been isolated in a yield of 4.8% from the wood of eastern hemlock (*Tsuga canadensis*). The water-soluble polysaccharide contained galactose, glucose, and mannose residues in a ratio of 1:1:3 and had $[\alpha]_D$ −8.2° and a $\overline{D.P.}_n$ of 44. Boundary electrophoresis and ultracentrifugation indicated the presence of a homogeneous polymer. A similar polysaccharide with a sugar ratio of 0.6:1:3 was obtained in a yield of 1.4%. A hexosan fraction, isolated together with an arabinoglucuronoxylan, amounted to 5.8% of the wood and had a sugar ratio of 1:1:2. A water-insoluble "glucomannan" fraction corresponded to 6.2% of the wood and contained galactose, glucose, and mannose residues in a ratio of 0.2:1:3. Application of various fractionation procedures to these hemicelluloses resulted in no further resolution. Galactoglucomannans were isolated also from the wood of amabilis fir (*Abies amabilis*), Engelmann spruce (*Picea engelmanni*), white pine (*Pinus strobus*), eastern white cedar (*Thuja occidentalis*), and *Ginkgo biloba*. These polysaccharides were similar to the galactoglucomannans from hemlock but in some cases exhibited a somewhat different sugar composition. The galactoglucomannans isolated are considered to be homogeneous triheteropolymers. The possibility that they were mixtures of a glucomannan and a galactoglucomannan was not deemed very likely. A review of previous work showed that, with one or two possible exceptions, all so-called "glucomannans" so far isolated contained 2–4% galactose residues. It is pointed out that these residues might well be integral parts of these hemicelluloses, which would then also be triheteroglycans. If this be the case, the wood of eastern hemlock, and probably also that of other gymnosperms, might contain as much as 15–20% of a closely related series of galactoglucomannans, differing mainly in their relative galactose content and perhaps also in their average molecular weight and degree of branching.

The presence of mannose residues in the wood of gymnosperms was established early (*1*) but their origin long remained entirely obscure. Many workers favored the view that at least some of the mannose was chemically combined with cellulose, since the complete removal of mannose residues from softwood celluloses proved to be an almost impossible task (*1*). Wise and Ratliff (*2*), for example, failed to produce a mannose-free cellulose from the wood of slash pine in spite of repeated alkaline extractions or prolonged acid hydrolysis. A true mannan, such as that present in vegetable ivory, has probably never been isolated from any wood in spite of at least two claims to the contrary (*3, 4*).

In 1952, Leech (*5*) isolated a disaccharide containing glucose and mannose residues from a slash pine alpha-cellulose. Four years later, Anthis (*6*) showed that this compound was a 4-*O*-β-D-glucopyranosyl-D-mannose. This indicated that some of the mannose residues in wood were chemically combined with glucose, but whether the latter originated from a cellulose or a hemicellulosic material was not known. Hamilton, Kircher, and Thompson (*7*), in 1956, reported the isolation of a true, diheteropolymer glucomannan from western hemlock (*Tsuga heterophylla*). This hemicellulose contained glucose and mannose residues in a ratio of 1:3, which were linked together by β-(1→4)-glycosidic bonds (*8*). The isolation of oligosaccharides containing both glucose and mannose units after partial hydrolysis

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of the glucomannan proved beyond any doubt that glucose and mannose were chemically combined in the polysaccharide. A glucomannan representing more than 80% of the mannose residues in white spruce wood (*Picea glauca*) was isolated by Timell and Tyminski (*9*) and found to have a similar constitution (*10*).

During the last four years many similar glucomannans have been isolated from the wood of various gymnosperm species, including the genera *Ginkgo*, *Larix*, *Picea*, *Pinus*, *Thuja*, and *Tsuga*. They have all been found to contain linear or slightly branched chains of (1→4)-linked β-D-mannose and β-D-glucose residues, usually in a ratio of 3 to 4:1, and probably distributed at random. Their number-average degrees of polymerization (determined after treatment with chlorous acid) fall within a range of 70 to 130.

The occurrence of galactoglucomannans in various softwoods has been referred to on several occasions by Hamilton and his co-workers (*11–14*). Recently, the isolation and constitution of such a polysaccharide from a mixture of slash pine (*Pinus elliottii*) and longleaf pine (*Pinus palustris*) was reported by Hamilton, Partlow, and Thompson (*15*). Conventional kraft wood pulp was extracted with 5% aqueous sodium hydroxide. The portion remaining in solution upon acidification was acetylated and the acetate was extracted with acetone. The acetone-insoluble fraction consisted of an arabinoxylan, while the acetone-soluble part on hydrolysis gave rise to galactose, glucose, and mannose in a ratio of 1:1:3. The yield, based on oven-dry wood, was 0.44%. Another method of isolation involved the use of Fehling's solution which had earlier been found by Adams (*16*) to give an insoluble complex with a galactoglucomannan isolated in a yield of 0.08% from white spruce wood.

Data obtained by the methylation and periodate oxidation techniques suggested the presence of a framework of β-(1→4)-linked D-glucose and D-mannose residues to which single, terminal side chains of D-galactose were directly attached by (1→6)-glycosidic bonds. The polysaccharide was soluble in water and had a specific rotation in this solvent varying from +5.2° to +12.5°, depending on the method of isolation. Numerous attempts were made to resolve the material further, all, however, without avail. Similar hemicelluloses were isolated also from western hemlock and redwood pulps. In these cases, the specific rotations varied from −8° to +17.5° and for the galactoglucomannans from hemlock the ratios of the constituent sugars were close to 1:1.5:5.

The possible occurrence of galactoglucomannans in softwoods has been discussed by Lindberg and his co-workers in connection with their studies on glucomannans from Norway spruce (*Picea abies*) (*17–19*) and Scots pine (*Pinus sylvestris*) (*20, 21*). These workers find little evidence for the presence of such a triheteropolymer in the wood of these two species. They have shown conclusively (*20, 21*) that residual lignin present in mixtures of hemicelluloses has to be removed in order to make these mixtures amenable to resolution, and this conclusion has been fully corroborated in this laboratory for hemicelluloses from both wood (*22*) and bark (*23*). Croon, Lindberg, and Meier (*20*) have pointed out that glucomannans, galactans and arabinogalactans might be present in wood. A β-(1→4)-linked galactan has been shown to be present in spruce compression wood by Bouveng and Meier (*24*). Quite recently, Meier (*19*) has reported the isolation of a 6-*O*-α-D-galactopyranosyl-D-mannose and an *O*-α-D-galactopyranosyl-(1→6)-*O*-β-D-mannopyranosyl-(1→4)-D-mannose, obtained by partial hydrolysis of a glucomannan from Norway spruce. The isolation of these oligosaccharides constitutes the first conclusive evidence that galactose and mannose residues are chemically combined in wood. These oligosaccharides could well have originated from a galactoglucomannan of the type described by Hamilton, Partlow, and Thompson (*15*), but Meier does not find this alternative very attractive and instead prefers to consider them as derived from a mixture of equal parts of a glucomannan and a galactomannan.

It is evident from this brief review that the exact origin of the mannose residues in softwoods is still open to discussion. The only thing that appears reasonably certain at present, is that wood celluloses do not contain any mannose units as integral constituents of their chain molecules (*25–27*). It was the object of this investigation to furnish more information as to the nature of the mannose-containing polysaccharides in softwoods, and particularly to establish whether true galactoglucomannans occur in these woods, and, if this were so, to what extent. Most of this paper is concerned with the isolation of mannose-containing hemicelluloses from the wood of eastern hemlock (*Tsuga canadensis*), but galactoglucomannans were isolated also from amabilis fir (*Abies amabilis*), Engelmann spruce (*Picea engelmanni*), white pine (*Pinus strobus*), eastern white cedar (*Thuja occidentalis*), and *Ginkgo biloba*.

RESULTS

The wood of eastern hemlock used was the same as that described previously (*28*) but a finer mesh size (60–80) was used in the present study and the analytical data were not all the same as the earlier ones. Chlorite holocelluloses were prepared by the method of Wise, Murphy, and D'Addieco (*29*), care being taken to avoid excessive loss of carbohydrates by interrupting the delignification short of completion. The data presented in Table I indicate that some loss of polysaccharides nevertheless occurred, especially of galactose-yielding material (*19, 24*). The increase in apparent uronic anhydride content has been observed elsewhere (*30, 31*) and was probably due to the oxidizing action of the chlorous acid.

The holocellulose was extracted with aqueous potassium hydroxide (*25*) which removed a mixture of poly-

Table I. Chemical Composition of Wood and Holocellulose from Eastern Hemlock

All values in per cent. Yield of holocellulose: 76.1%

Component	*Wood*	*Holocellulose*
Cellulose	42.0	...
Klason lignin	32.3	7.5
Pentosan	6.6	7.8
Ash	0.2	2.4
Acetyl	1.7	...
Uronic anhydride	3.3	5.3
Residues of:		
Galactose	1.7	1.4
Glucose	45.0	64.3
Mannose	11.2	13.0
Arabinose	0.7	1.0
Xylose	4.0	4.5

Table II. Yields of Holocellulose and Hemicelluloses in Four Experiments

All values in per cent of extractive-free wood

Experiment no. →	*I*	*II*	*III*	*IV*
Holocellulose	76.1	71.6	72.9	66.9
KOH-extract	17.9	15.7	17.1	12.9
NaOH-borate-extract	6.9	7.2	7.2	5.7
Total hemicelluloses	24.8	22.9	24.3	18.6

saccharides giving uronic acids, galactose, glucose, mannose, arabinose, and xylose on hydrolysis. The residue was exhaustively extracted with aqueous sodium hydroxide containing borate (*32*). The hemicellulose thus obtained contained galactose, glucose, and mannose residues in addition to minor amounts of pentose and uronic acid sugars. The alkali-insoluble residue gave glucose and a very faint trace of mannose on hydrolysis and was obviously cellulose. It was not further examined. The yields of hemicelluloses, summarized in Table II, evidently decreased with increasing degree of delignification, and especially so for the fourth holocellulose. This was undoubtedly due to the fact that once the protecting lignin was removed, the underlying carbohydrates were rapidly oxidized and degraded by the acid chlorite. The average yields of holocellulose, KOH-extract, and NaOH-borate–extract were 71.9, 15.9, and 6.7%, respectively.

The material removed with sodium hydroxide–borate was purified by one treatment with aqueous barium hydroxide (*33*). The polysaccharide now contained glucose and mannose residues in a ratio of 1:3.0 and was obviously what has usually been referred to as a glucomannan. No pentose sugars could be detected, but some galactose residues were still present in the polysaccharide and could not be eliminated.

The mixture extracted with potassium hydroxide was treated with barium hydroxide to give a soluble and an insoluble portion (referred to as "crude galactoglucomannan") which were each again treated with barium hydroxide. The two fractions precipitated with barium hydroxide (galactoglucomannans I and II) contained galactose, glucose, and mannose in addition to minor amounts of arabinose and xylose residues. The fraction remaining in solution on hydrolysis gave galactose, glucose, mannose, arabinose, and xylose. The fractionation procedure is summarized in Table III and the yields of the various fractions are given in Table IV, where the above, unprecipitated part is referred to as "soluble portion." The sugar composition of the various fractions is presented in Table V together with their specific rotation. The second precipitation of the crude galactoglucomannan apparently did not alter its relative hexose composition and eliminated only half of the pentose-yielding material.

Attempts to resolve the two galactoglucomannans and the glucomannan by further fractionation all failed. Additional treatments with barium hydroxide did not change their relative sugar composition. Addition of Fehling's solution to an alkaline solution of galactoglucomannan I gave a product with almost the some sugar composition. The soluble portion referred to earlier gave no precipitate when treated similarly. Acetylation gave an acetone-soluble acetate in a yield of only 50%, deacetylation of which with sodium methoxide produced a material in a yield of 25%, containing galactose, arabinose, and xylose in an approximate ratio of 1:1:5. A similar mixture was obtained in an earlier attempt to purify an arabinoglucuronoxylan from Ginkgo wood by repeated precipitation with barium hydroxide (*34*). If the arabinoxylan undoubtedly present in the soluble portion is assigned a specific rotation in water of −65° (*35*, *36*, *37*), the rotation of the mixture (−33°) would correspond to a specific rotation of −8° for the hexosan portion, or the same value as that found for the two galactoglucomannans.

The data obtained for the sugar composition of the wood are compared in Table VI with the corresponding values calculated from the relative amounts and composition of the hemicellulose fractions. Except perhaps for the mannose, the agreement is reasonably good,

Table III. Isolation of Mannose-Containing Hemicelluloses from Hemlock Wood

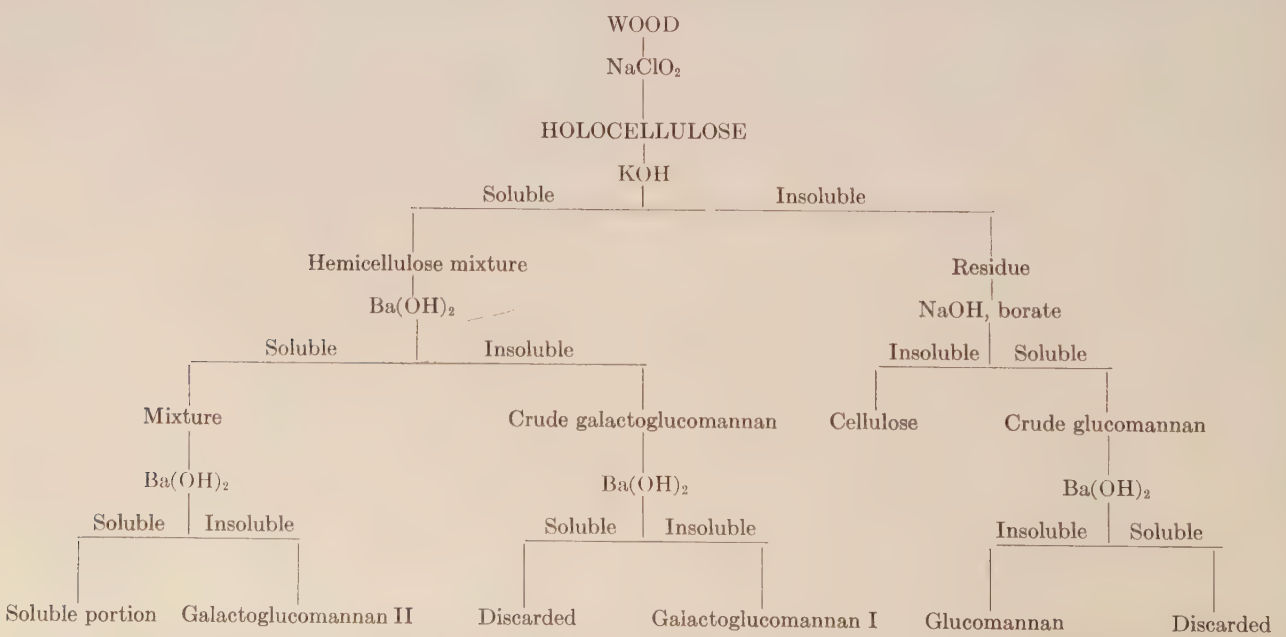

Table IV. Average Yields of Holo- and Hemicelluloses from Hemlock Wood

All values in per cent of extractive-free wood

Component	%
Holocellulose	71.9
KOH-extract	15.9
NaOH-Borate-extract	6.7
Galactoglucomannan I	4.2
Galactoglucomannan II	1.4
Glucomannan	6.2
Soluble portion	
Hexosan fraction	5.8
Pentosan fraction	4.6

thus indicating that most of the carbohydrates in the wood had been accounted for.

A portion of galactoglucomannan I was subjected to partial hydrolysis with weak acid. The first sugar to appear in the hydrolyzate was galactose, followed by mannose, and, much later, glucose. The galactoglucomannan studied by Hamilton, Partlow, and Thompson (*15*) behaved similarly on hydrolysis, showing the considerable lability toward acids of the (1→6)-galactosidic bond. The acetate derivative of the galactoglucomannan was soluble in acetone. Osmotic pressure measurements in chloroform–ethanol solutions of this derivative indicated the presence of 44 glucose and mannose residues in the backbone of the average macromolecule.

When subjected to boundary electrophoresis according to Tiselius in a borate solution, galactoglucomannan I gave two peaks, one major and one minor and faster moving, representing approximately 5% of the total. The first maximum undoubtedly corresponded to the galactoglucomannan, the second to the acidic arabinoxylan present as an impurity in this sample.

On ultracentrifugation the sample gave two maxima, one of which corresponded to 5 to 10% of the material and which sedimented rapidly. This probably represented the xylan impurity. The main part of the specimen gave a sharp peak which broadened somewhat on continued sedimentation while the sedimentation constant appeared to remain unchanged. Both techniques thus indicated the homogeneous nature of the galactoglucomannan.

Chlorite holocelluloses were prepared in the usual way from the wood of five other gymnosperm species and were extracted with aqueous potassium hydroxide. The mixture of hemicelluloses removed was treated with barium hydroxide which precipitated a galactoglucomannan fraction. All polysaccharides thus obtained contained little or no pentose residues and were not further purified. A summary of the yield, specific rotation, and sugar composition of the fractions is presented in Table VII, including the corresponding data for the hemicellulose from hemlock. The relative amounts of galactoglucomannans obtainable by this technique

Table VI. Comparison between Found and Calculated Values for Neutral Sugar Residues Derived from Hemicelluloses in Hemlock Wood

All values in per cent of extractive-free wood

Sugar residue	*Galactose*	*Glucose*[a]	*Mannose*	*Arabinose*	*Xylose*
Found[b]	1.7	3.0	11.2	0.7	4.0
Calculated[c]	1.9	3.4	9.3	0.6	4.0

[a] Difference between percentages of anhydroglucose and cellulose.
[b] Found by direct analysis of the wood.
[c] Calculated from yield and composition of hemicelluloses.

apparently varied considerably from one species to another. There were also noticeable differences in sugar composition.

DISCUSSION

A summary of the yield and hexosan composition of the hemlock polysaccharides is given in Table VIII where the hexose-yielding part of the soluble portion has also been included. The sugar composition and calculated rotation of this fraction tentatively suggested that it might be a galactoglucomannan in admixture with an arabinoglucuronoxylan of the type usually occurring in softwoods. Both precipitation of a Ginkgo xylan (*34*) with barium hydroxide and acetylation of the present mixture largely eliminated glucose and mannose but left a considerable part of the galactose residues associated with the pentose sugars. This would suggest the presence of a galactan or an arabinogalactan rather than a galactoglucomannan. The composition of this fraction will evidently remain in doubt until further experimental data became available.

The polysaccharides in Table VIII are listed in order of decreasing solubility in water or aqueous alkali of either their barium hydroxide complex or of the hemicelluloses themselves. The results of Hamilton and his co-workers (*15*) strongly suggest that all galactose residues were present as single, terminal side-chains. Introduction of side chains into a linear polysaccharide of the dimensions of the present hemicelluloses evidently confers water-solubility on the polymers, and higher the more numerous the side chains. The first polysaccharide had the highest solubility in water and it also contained the highest proportion of galactose residues. The glucomannan carried relatively few galactose residues and was soluble only in aqueous sodium hydroxide. It probably had a much higher molecular weight than the galactoglucomannans and this, of course, would also tend to lower its solubility in water. It is interesting to note in this connection that the true mannans occurring in vegetable ivory are even less soluble in aqueous alkali than the wood glucomannans (*38*, *39*). Introduction of a few side-chains into alkali-soluble xylans often render these polysaccharides soluble in water. Such side chains may consist of acetyl (*40*, *41*), 4-*O*-methylglucuronic acid, or arabinose groups.

There appears to be little doubt that the two galacto-

Table V. Relative Sugar Composition of Hemicelluloses from Eastern Hemlock

All values in per cent

Component	*Galactose*	*Glucose*	*Mannose*	*Arabinose*	*Xylose*	$[\alpha]_D^{19}$[a]
Soluble portion	13	14	29	6	38	−33°
Crude galactoglucomannan	16	20	54	4	6	− 7°
Galactoglucomannan I	19	19	57	2	3	− 8.2°
Galactoglucomannan II	12	21	59	2	6	− 8°
Glucomannan	4	24	72	Nil	Nil	−40°[b]

[a] 1% solution in water.
[b] 1% solution in 10% NaOH.

Table VII. Yield, Specific Rotation, and Sugar Composition of Galactoglucomannans from the Wood of Six Gymnosperm Species

Species	*Yield, %*[a]	$[\alpha]_D^{19}$ [b]	*Galactose*	*Glucose*	*Mannose*
Eastern hemlock (*Tsuga canadensis*)	4.2	−8.2°	1.0	1.0	3.0
Amabilis fir (*Abies amabilis*)	4.0	−5.6°	1.0	1.0	3.0
Engelmann spruce (*Picea engelmanni*)	2.0	−7.3°	1.0	1.0	3.0
White pine (*Pinus strobus*)	1.6	−5.5°	1.0	1.0	1.8
Eastern white cedar (*Thuja occidentalis*)	0.90	−8°	1.0	2.4	3.3
Ginkgo biloba	0.75	−7°	1.0	1.0	1.4

[a] Based on extractive-free wood.
[b] 1% solution in water.

glucomannans were chemically homogeneous polymers, that is, true triheteroglycans. This is indicated by the fact that their carbohydrate composition remained essentially unchanged during fractionations and also by the behavior of the first specimen on electrophoresis and ultracentrifugation. The sugar composition of galactoglucomannan I was identical to that reported by Hamilton, Partlow, and Thompson (*15*) and very similar to that obtained by Adams (*16*). The most interesting feature is the high yields in which the present galactoglucomannans were obtained, 5.6% by weight of the wood if only fractions I and II are included. The possibility that these polysaccharides consisted of mixtures of a glucomannan and a galactomannan cannot, of course, be entirely excluded on the basis of the present evidence. Almost all galactomannans occur in nature as reserve polysaccharides in the endosperm of seeds. The carbohydrates in wood, on the other hand, undergo no further changes once they have been laid down in the cell wall (*42*). It would be rather peculiar, therefore, if wood cells contained appreciable amounts of this polysaccharide. Structural studies, involving especially partial acid or enzymic hydrolysis, are expected to furnish more information on this point.

It is evident from the results summarized in Table VII that galactoglucomannans occurred in all six species studied here. Amabilis fir seems to contain as much of this polysaccharide as eastern hemlock while the yields from the other species were lower. The specific rotations of the polysaccharides were all approximately the same but the relative sugar compositions varied somewhat. The first three hemicelluloses in Table VII were chemically very similar. They were obtained in higher yields than the remaining four, and the different sugar ratios observed for the latter might not be entirely representative of the total galactoglucomannan portion of these woods. It cannot be decided on the basis of the present evidence whether the last four species contained a lower percentage of galactoglucomannans than the first two, or whether characteristics such as a lower average molecular weight or a higher degree of branching rendered these polysaccharides less amenable to precipitation with barium hydroxide.

The galactoglucomannan from Engelmann spruce, when subjected to partial acid hydrolysis, gave a series of oligosaccharides, four of which have been tentatively characterized as mannobiose, mannotriose, mannosyl glucose and glucosyl mannose. The isolation and

Table VIII. General Characteristics of the Mannose-Containing Hemicelluloses in Hemlock Wood

Hemicellulose fraction	*Yield, %*	*Galactose*	*Glucose*	*Mannose*	$[\alpha]_D^{19}$
Hexosan fraction of soluble portion	5.8	1	1	2	− 8°
Galactoglucomannan II	1.4	0.6	1	3	− 8°
Galactoglucomannan I	4.2	1	1	3	− 8°
Glucomannan	6.2	0.2	1	3	−40°

unequivocal identification of tri- or tetrasaccharides containing both galactose, glucose, and mannose residues would be highly desirable since it would furnish a direct proof of the triheteropolymer nature of the polysaccharide.

The final problem to be considered involves the nature of the least soluble hexosan fraction obtained from hemlock wood, so far referred to as a "glucomannan." This polysaccharide still contained 4.0% galactose residues which could not be removed by further fractionation. A re-examination of other glucomannans previously investigated in this laboratory showed that those from softwoods all contained galactose residues, including a glucomannan from white spruce which had previously (*9, 10*) been reported to be devoid of such residues. Delignification of a glucomannan from white pine (*22*), followed by repeated precipitation with barium hydroxide failed to eliminate all galactose residues in this polymer. A review of earlier and current investigations reveals the same phenomenon, as can be seen from Table IX which summarizes the characteristics of almost all glucomannans so far isolated from gymnosperm woods. Only in two cases have galactose residues been reported to be absent (*7, 44*). One of these investigations concerned the first glucomannan ever isolated from wood (*7*). This hemicellulose was isolated from a conventional sulfite pulp. As was mentioned above, the galactose residues present in galactoglucomannans are evidently rather labile toward acid hydolysis. It has also long been known (*52*) that galactose appears in the cooking liquor during the early stages of a sulfite cook. The possibility that galactose

Table IX. General Characteristics of Softwood Glucomannans So Far Investigated

Species	*Galactose, %*	*Mannose/Glucose*	$[\alpha]_D$	$\bar{P}_n$	*Ref.*
Norway spruce (*Picea abies*)	Present	3.5–4.0	−39°	68–100	*17–19*
Engelmann spruce (*Picea engelmanni*)	3.5	3.3	−40°	...	*43*
White spruce (*Picea glauca*)	3.0	3.1	−34°	107	*9, 10*
Sitka spruce (*Picea sitchensis*)	Nil	2.5	−33°	...	*44*
Sitka spruce	Present	9–15	−28°	...	*45*
Jack pine (*Pinus banksiana*)	2.9	2.9	−26°	...	*46*
White pine (*Pinus strobus*)	1.8–3.0	2.7–3.8	−32°	95	*22*
Scots pine (*Pinus sylvestris*)	4.0	3.5	−31°	97	*20, 21*
Loblolly pine (*Pinus taeda*)	3.7	2.7	−20°	...	*47, 48*
Eastern hemlock (*Tsuga canadensis*)	4.0	3.0	−40°	...	...
Western hemlock (*Tsuga heterophylla*)	Nil	3	−38°	130	*7*
Western red cedar (*Thuja plicata*)	1.5	2.5	−37°	...	*49*
Amabilis fir (*Abies amabilis*)	3.0	3.3	−40°	...	*50*
Ginkgo biloba	4.2	3.6	−36°	96	*51*

residues originally present in the western hemlock glucomannan could possibly have been lost during the pulping operation cannot therefore be excluded.

All other softwood glucomannans have invariably been found to contain galactose units, usually 3 to 4%. Inspection of the data in Table IX reveals that the glucomannans are very similar with respect to relative sugar composition, specific rotation, and degree of polymerization. The average ratio between the galactose, glucose, and mannose residues is close to 1 : 8 : 24.

Most workers have paid little attention to these galactose residues, usually dismissing them as originating from small amounts of galactose-containing polysaccharides associated with the glucomannans. Jones and co-workers (*47*) considered their mannose-containing polysaccharide from loblolly pine to be a mixture of a glucomannan and a galactoglucomannan, a suggestion similar to that later made by Meier (*19*). In a subsequent study, Jones and Painter (*48*) reported the isolation of 2,3,4,6-tetra *O*-methyl-D-galactose from the methylated glucomannan. The galactose was assumed to occur as terminal, nonreducing end groups in the hemicellulose. Hamilton and Partlow (*49*) obtained the same tetra-*O*-methylgalactose (in addition to some di-*O*-methylgalactose) on methylation and subsequent hydrolysis of a glucomannan from western red cedar. They did not consider the compound to be structurally significant as it was probably derived from an occluded galactoglucomannan which could be completely removed in a later experiment. A tetra-*O*-methylgalactose was also isolated by Dutton and Hunt (*45*) after methylation of a glucomannan from Sitka spruce. These workers suggested that it was derived from a short-chain polysaccharide, easily removed on dialysis of the methylated hemicellulose.

Croon, Lindberg, and Meier have reported the isolation of a glucomannan fraction from Scots pine (*21*) which contained 11% galactose in addition to 5.5% xylose residues. After delignification of the hemicellulose, all xylose could be removed, but it appears significant that even after one precipitation with barium hydroxide and two subsequent treatments with Fehling's solution, 1 to 2% of the galactose residues persisted in the polysaccharide. In a recent paper, Bishop and Cooper (*46*) have described the isolation of a glucomannan from jack pine, where half of the galactose residues were accounted for as tetra-*O*-methylgalactose. The galactose could not be eliminated by complexing with copper and the polysaccharide was electrophoretically homogeneous. It was therefore concluded that the galactose units were integral parts of the polymer and did not originate from a contaminant.

It is difficult to draw any definite conclusions as to the nature of the galactose residues usually associated with softwood glucomannans from the data presently available. The fact that the galactose residues have so often been found to occur as terminal, nonreducing units, would make the presence of a galactan contaminant rather improbable. This conclusion is further substantiated by the recent isolation of a galactosyl mannose and a galactosyl mannobiose from a spruce glucomannan (*19*). The evidence does not entirely exclude the possibility that a galactomannan could be associated with the glucomannan, as has been suggested (*18*, *19*). However, the fact that most softwoods probably contain significant quantities of galactoglucomannans, as evidenced by the results reported both by Hamilton and his co-workers (*15*) and in this paper, would make the presence of a galactoglucomannan contaminant seem more likely.

The different solubility properties of the "glucomannans" and the galactoglucomannans should make these polymers easy to separate from each other. All glucomannans so far studied were no doubt carefully purified, yet all of them contained approximately the same relative amount of galactose residues. On the other hand, these galactose units, if attached as (1→6)-linked terminal side chains would easily be lost, first because of the acid-lability of this type of galactosidic bond and, second, because after a depolymerization those fragments of the polysaccharide which contained many galactose groups would be most easily soluble in water or aqueous alkali. The situation here is similar to that recently discussed (*34*) with respect to the arabinofuranose side-chains present in softwood xylans. All these xylans, in the opinion of the present author, invariably contain arabinose side-chains, and in the few instances where their absence has been reported, these acid-labile groups had probably been accidentally lost.

It appears from the above, albeit admittedly indirect, evidence that the possibility should be seriously considered that the galactose residues present in the so-called "glucomannans" from the wood of gymnosperms are actually integral parts of these polysaccharides, which should then be classified as triheteropolymer galactoglucomannans. Additional experimental data will undoubtedly in the near future serve to solve this problem.

CONCLUSIONS

The present evidence strongly suggests that the wood of eastern hemlock contains a minimum amount of 5 to 6% by weight of the wood of galactoglucomannans, and possibly as much as 11 to 12%. If, as appears conceivable, the "glucomannan" portion is actually also a galactoglucomannan, the total content of such polysaccharides would amount to 17 to 18%. The galactoglucomannans in hemlock wood apparently constitute a series of closely related hemicelluloses, differing mainly in their relative galactose content and average molecular weight. Other differences, such as degree of branching or attachment and distribution of sugar residues, might also exist. Wood from other gymnosperms also contain galactoglucomannans but their relative amount and average sugar composition might vary from one species to another. Most of the glucomannans so far studied contain galactose, glucose, and mannose residues in a ratio of 1 : 1 : 3, have a low specific rotation, and are soluble in water.

The extraction and purification sequence used here is quite useful for separating polysaccharides after prior removal of noncarbohydrate constituents. It has been successfully applied also to wood from angiosperms (*53*) as well as to bark from birch (*23*) and from various softwoods (*54*).

EXPERIMENTAL

Paper Chromatography

Solvent systems used for separating sugars were (A) ethyl acetate – pyridine – water (8 : 2 : 2) and (B) ethyl

acetate – acetic acid – water (9 : 2 : 2) Separations were carried out on Whatman no. 1 filter papers by the descending technique. The spray reagent was *o*-aminodiphenyl (*55*). For quantitative sugar analysis, mixtures were resolved with solvent system A, the sugars were eluted with appropriate amounts of water, and analyses were carried out in duplicate by the method of Timell, Glaudemans, and Currie (*55*). The reproducibility of this procedure was excellent when using solvent A and the values could be considered accurate within ± 1 or 2 relative per cent.

Preparation of Holocelluloses

Extractive-free wood from eastern hemlock (60 – 80 mesh, 1200 g.; moisture content 7.9%) was suspended together with some silicone wetting agent in 18 liters of water at 70 to 80°C. in a round-bottom flask fitted with a stirrer. Acetic acid (120 ml.) and sodium chlorite (360 g.) were added and the reaction was allowed to proceed for 1 hr. The same amounts of reagents were then added every hour for an additional period of 3 hr. The partly delignified product was allowed to settle and was washed several times by decantation with tap water. The solids were transferred to a large Büchner funnel and washed by filtration with distilled water until free from acid. The water was replaced by ethanol and the white product was air-dried. Yield: 915 g., moisture content 8.0%, corresponding to 76.1% of the wood. Table I gives the analytical data for this holocellulose. Three additional batches of holocelluloses were prepared in the same way. The yields obtained were 71.6, 72.9, and 66.8%, respectively.

Extraction of the Holocellulose with Alkali

Holocellulose from the first experiment (840 g. on a dry basis) was suspended in 6 l. of 24% (w./w.) aqueous potassium hydroxide together with some wetting agent in a 12-l., round-bottom flask, fitted with a vent to the atmosphere. Most of the air in the flask was displaced with nitrogen. The mixture was vigorously shaken for 8 hr. at room temperature after which it was allowed to stand overnight. The solution was removed by filtration through two large, sintered-glass filter funnels (Pyrex Coarse) and the solid residue was washed with 4 l. of water. The combined extract and washings were poured into four times their volume of 100% ethanol (30 to 40 l.) containing an excess of glacial acetic acid (3 to 4 l.). The precipitate was recovered by filtration over paper on a large Büchner funnel and washed in succession with 70% aqueous ethanol, 100% ethanol, and petroleum ether (b.p. 30 to 60°C.). The material was dried *in vacuo* over solid potassium hydroxide for five days to give an almost white powder (198 g.), corresponding to 17.9% of the original wood.

The solid material remaining after treatment with aqueous potassium hydroxide was washed with large quantities of distilled water. While still wet, it was extracted in the same way with 17.5% aqueous sodium hydroxide to which 4% by weight of boric acid had been added. The extract was recovered as described above to give a white powder (76 g.), corresponding to 6.9% of the wood. The residual material was acidified with dilute acetic acid and washed with water until neutral. Yield: 460 g., corresponding to 42% of the wood. This was a pure cellulose. The yields obtained with the four holocelluloses are summarized in Table II.

Purification of the Glucomannan

The combined sodium hydroxide – borate extracts (299 g., 6.7% of the wood) were divided into two portions (150 g. and 149 g., respectively) which were separately dissolved in 10% sodium hydroxide (3 l.). Aqueous, 5% barium hydroxide (6 l.) was added dropwise over a period of 3 hr. The precipitate formed was recovered on the centrifuge and was washed twice with 5% aqueous sodium hydroxide. It was then shaken with ice-cold, 50% aqueous acetic acid and the mixture was poured into four times its volume of ethanol. The precipitate was recovered in the usual way to give a white powder (136 g. in the first, 140 g. in the second experiment), corresponding to 6.20% of the original wood. The polysaccharide contained only hexose sugar residues.

Isolation of Galactoglucomannans

The combined potassium hydroxide extracts (704 g., 15.9% of the wood) constituted a mixture of polysaccharides. A portion (150 g.) was dissolved in water (1.5 l.) after which 20% aqueous potassium hydroxide (1.5 l.) was added to the brown solution. Aqueous, 5% barium hydroxide (6 l.) was added dropwise. The precipitate formed was recovered on the centrifuge and washed three times with water after which the hemicellulose was recovered as described above to give 53 g. of a crude galactoglucomannan. The combined centrifugate and washings were combined and concentrated to 3 – 4 l. *in vacuo* after which the solution was poured into four times its volume of ethanol containing an excess of acetic acid to give 100 g. of a polysaccharide mixture. Yields of galactoglucomannan and mixture: 5.6 and 10.6% of the wood, respectively.

The crude galactoglucomannan (52 g.) was dissolved in water (500 ml.) and 20% aqueous potassium hydroxide was added (500 ml.). Barium hydroxide solution (2 l.) was added dropwise. The precipitate was recovered by centrifugation, washed three times with water, and treated in the usual way to yield galactoglucomannan I (39.3 g., 4.2% of the wood). The alkaline centrifugate was discarded. The material remaining in solution after the first addition of barium hydroxide (100 g.) was treated in the same way with barium hydroxide to yield what was probably a mixture of a hexosan and an arabinoglucuronoxylan (98 g., 10.4%) and galactoglucomannan II (12.9 g., 1.4%).

Isolation of Galactoglucomannans from Other Species

Wood meal (40 – 60 mesh, 100 g.) was treated with acetic acid and sodium chlorite as described before. For unknown reasons, six treatments were necessary to attain the degree of delignification reached after four treatments on the larger scale. The holocelluloses were exhaustively extracted with 24% potassium hydroxide to yield a mixture of hemicelluloses. One precipitation with barium hydroxide gave galactoglucomannans containing only small amounts of arabinose or xylose residues. The experimental data are presented in Table X. Similar results were obtained when barium hydroxide was added directly to the alkaline extract from the holocelluloses.

Graded Acid Hydrolysis of Galactoglucomannan I

Galactoglucomannan I (1 g.) was dissolved in 0.02 *N* HCl (100 ml.) and the solution was heated to 97°C. for 15 hr. Aliquots (5 ml.) were withdrawn every hour, neutralized with Amberlite IR-45 exchange resin, concentrated, and examined by paper chromatography (solvents A and B). Galactose and arabinose were the first sugars to appear, followed by mannose and, much later, glucose.

Various Measurements

Specific rotations were determined with aqueous solutions of the water-soluble polysaccharides and with 10% aqueous sodium hydroxide for the glucomannan. The solutions were clarified by ultracentrifugation at 40,000 r.p.m. for 30 min. Duplicate aliquots (5 ml. each) of the clear solutions were added to 100 ml. of acetone and the precipitate formed was collected on a sintered-glass filter crucible (Pyrex Coarse) provided with a mat of asbestos fibers. After washing with ethanol and petroleum ether, the precipitates were dried at 100°C. for 2 hr. and weighed. The concentrations used varied between 0.8 and 1.4 g. per 100 ml. Rotations were measured with sodium light at a temperature of 18 to 19°C. In four cases a Rudolph photoelectric polarimeter was used, permitting measurements within ±0.003°.

Table X. Isolation of Galactoglucomannans from Five Gymnosperm Species

All values in per cent of extractive-free wood

Species	*Lignin*	*Holocellulose*	*KOH-extract*	*Galactoglucomannan*
Amabilis fir	29.2	71.1	19.1	4.0
Engelmann spruce	28.0	73.0	13.4	2.0
White pine	29.3	71.0	19.1	1.6
White cedar	30.7	73.1	19.3	0.90
Ginkgo biloba	33.8	69.8	18.3	0.75

Free boundary electrophoresis was carried out with a Spinco Model H apparatus. Galactoglucomannan I (100 mg.) was dissolved in 10 ml. of water and enough borax was added to make the solution 0.05 *M*. A small precipitate was formed on addition of the salt and was removed by centrifugation. One large and one very small (5%) peak were observed in addition to a small, stationary salt boundary. Sedimentation studies were carried out with a Spinco ultracentrifuge and with a 1.4% solution of galactoglucomannan I in water. One major and one minor and faster sedimenting peak were observed.

A portion of galactoglucomannan I was converted to the acetate derivative by treatment with acetic anhydride in a pyridine – formamide solution as described previously (*56*). The reaction mixture was poured into 2% aqueous hydrochloric acid and the solution was extracted with chloroform. The chloroform solution was extracted with aqueous sodium bicarbonate and then with water, after which it was dried over anhydrous sodium sulfate and evaporated to dryness to give a crisp solid (70% of theory). The brown product was soluble in acetone. Osmotic pressure measurements were carried out in a 9:1 (v/v) mixture of chloroform and ethanol as described in detail elsewhere (*56*). The value of $(h/w)_{w=0}$ was 1.63, corresponding to a molecular weight of 15,800. If the galactose residues in the polysaccharide are assumed to occur as single, terminal side chains, this corresponds to a number-average degree of polymerization of 44 (number of mannose and glucose residues in the main chain).

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Synthetic Latices as Binders for the Clay Coating of Paper

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A systematic study was made of the properties of paper coatings containing 10–20% of synthetic latex as binders for clay-pigment coating. Five latices, styrene–butadiene, acrylate copolymer, polyvinyl acetate and two vinyl acetate–dibutyl maleate copolymers were investigated both as all-latex pigment coatings and as 50–50 starch latex binders. The properties examined included pick resistance (adhesion and binding strength), varnish holdout, gloss, stiffness, smoothness, brightness and opacity. Vinyl acetate homopolymer was found to have poor binding power although the copolymers show promise for some applications. The effect of the polymer properties on the coating properties was studied, and the reasons for the wide variation in properties discussed in some detail. Since the latices were all thermoplastic the effect of the temperature and method of drying the coatings on the properties was carefully studied and correlated with the behavior of the free polymer. The method of water removal from the coating and the temperature at which film formation takes place is shown to affect the binding power to a considerable degree. Finally the effects of the temperature and pressure of the supercalendar on the gloss, smoothness, opacity and varnish holdout of the coating was investigated and correlated with the type of polymer used.

There has been considerable interest in recent years in the use of synthetic latex binders for the clay coating of paper. The latices can replace all or part of starch and casein, the usual pigment binders for paper coating, and confer superior gloss, binding strength, wet rub resistance, and other desirable properties to the coated sheet. Styrene–butadiene copolymer latices containing about 60% of styrene were pioneered (*1*) by The Dow Chemical Co. Early patents covering this application were obtained by the S. D. Warren Co. In recent years other polymers have been developed for this use; in particular the acrylates and acrylate copolymers (*2*) have found extensive use for the on-machine coating of paperboard and for breadwrapping papers. In England butadiene–methyl methacrylate copolymer latices have been used successfully (*3*) whereas, in Germany the acrylate–vinyl acetate copolymers have gained wide acceptance. In the U.S.A. polyvinyl acetate polymers (*4*) and copolymers are also under intensive development.

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In this paper the overall effect of changes of the type of polymer on the coating properties are discussed. No comparative study of this type has been reported in spite of the great interest in various polymer latices for paper coating.

Five different polymers were studied both as all-latex binders and as 50-50 latex-starch blends. Exact comparison between polymers is difficult since the particle size and stabilizing systems, the pH, viscosity, and surface tension all vary from latex to latex. The five latices studied had somewhat similar particle sizes, and for practical purposes were comparable, since each was stabilized to an optimum degree for satisfactory storage, shipping, and use. An interesting and informative study of the effect of various changes in the properties of latices on their performance as clay-coating binders has been presented by Tabor and Stein (*5*). Changes in the stabilizing system of a latex reflect more in its rheological properties, performance in a high-speed coating operation, and sticking at the calender rolls than in the properties of the finished coating such as are described here.

The properties of clay-coated papers depend on many variables, which may be grouped as follow: (a) the composition of the coating mix and the weight applied, (b) the quality of the base paper or board and (c) the method of application of the coating, and (d) the drying and calendering conditions. In this study the coating weight, the base paper, the method of application, and the pigment were all held constant and only the amount and type of binder was varied. Since the binders used were thermoplastic the effect of changing the drying and calendering conditions was also investigated.

EXPERIMENTAL

Table I summarizes the properties of the five latices used. The styrene–butadiene and acrylate copolymers were standard, commercial, paper-coating latices. The others were experimental latices specially selected for this study. The coating colors were prepared both with an all-latex system and a 50-50 starch-latex binder system. Table II summarizes the ingredients and procedures used. The coatings were applied using a wire-wound rod to 9 by 12 in. sheets of 42-lb. (59 g.s.m.) bleached kraft paper (White Ariel Bond Sub 16, 25 by 38 grain sheet, Champion Paper and Fiber Co., Hamilton, Ohio) at a weight of 16–17 lb.

Table I. Properties of Latices Studied

Type	Particle size, μ	Surface Tension, dynes/cm.	Density of polymer, g./cc.	pH	Solids content, %
Styrene–butadiene (60-40)	0.2	31	1.01	10.5	48
Acrylate copolymer	0.1	46	1.09	9.5	48
Vinyl acetate	0.1	37	1.19	6.0	50
Vinyl acetate–dibutyl maleate (75-25)	0.1	41	1.17	6.3	54
Vinyl acetate–dibutyl maleate (65-35)	0.1	36	1.15	6.3	54

(22–24 g.s.m.) per TAPPI ream (25 × 40—500). They were dried in an air-circulating oven at three different temperatures: 3 min. at 30°C., 1.5 min. at 90°C., and 1 min. at 140°C. The dried sheets were conditioned for 24 hr. at 73°F. and 50% R.H. before supercalendering at a controlled temperature and pressure. Each sheet was given three passes through the nip. The temperatures of the supercalender rolls were measured by a steel thermometer leading to somewhat lower readings than actual; pressures were measured by the pressure gage on the supercalender. The sheets were again conditioned 24 hr., before testing.

The binding strength was measured using the I.G.T. printability tester with spring drive B using I.P.I. standard black picking inks nos. 2, 3, and 4. All results were converted to the speeds using no. 2 ink by duplicating with at least two binder levels, plotting and converting graphically. Controls using the styrene–butadiene latex were added to each set of experiments.

The varnish holdout was measured using various concentrations of xylene in Sherwin-Williams overprint varnish no. XLB-C26. An oil-soluble red dye was added to make penetration more visible. Thirty seconds of contact time was used for the test.

Gloss was measured with a Bausch and Lomb gloss meter; *smoothness*, with a Bekk smoothness tester, and *stiffness*, with the Gurley tester. *The brightness* of the supercalendered sheets was measured using a Hunter multipurpose reflectometer and *opacity*, with a Bausch and Lomb opacity meter. *Wet rub* resistance measurements were attempted but it was found difficult to obtain suitable numerical results using the normal procedures.

Table II. Coating Color Preparation

All-Latex Binder

Clay dispersion:

600 g. A.S.P. 600 clay (Minerals and Chemicals Corp. of America, Menlo Park, N. J.) in 300 cc. of distilled water containing 0.7% tetrasodium pyrophosphate, stirred for 5 min. Weigh 150 g. of this dispersion into 8-oz. bottle and add enough latex to give desired binder level. Adjust water to require total solids, stir for 5 min. and filter through100-mesh screen.

50-50 Starch-Latex Binder

Starch Solution:

200 g. Flokote 64 (National Starch and Chemicals Corp., Plainfield N. J.) in 400 cc. water, stir, and heat up to 190°F. in water bath with stirring and cool to room temperature with stirring

Coating mix:

150 g. of above clay dispersion, add enough starch solution to give correct starch content, stir, and add enough latex to give correct binder level. Adjust water to required total solids, stir for 5 min., and filter through 100-mesh screen.

Table III. Binding Strength of Polymer Latices at Various Pigment-Binder Ratios Dried for 1 1/2 Minutes at 90°C. and supercalendered at 55°C. and 5000 lb./foot

I.C.T. Printability Tester

Pigment–binder ratio →	100% Latex 10	12	14	16	18	50-50 Latex-starch 14	16	18	20
Styrene–butadiene	465	535	655	805	900	400	630	760	860
Acrylate copolymer	459	590	755	855	955	240	350	540	700
Polyvinyl acetate	305	485	555	654	655	260	240	120	640
Vinyl acetate–dibutyl maleate									
Copolymer 75-25	330	420	580	670	750	400	420	540	590
Copolymer 65-35	230	315	405	575	680	210	400	540	660

RESULTS

The effect of the drying temperature and supercalendering conditions on the various coating properties examined will be discussed separately. The properties obtained at the standard 90°C. drying and at 55°C. and 5000 lb. per linear foot calendering will be discussed first. Table III gives the binding strength figures at a number of binder levels. It can be seen that the binding strength, as would be expected, increases steadily with binder content and that the all-latex binders are consistently stronger than the starch-latex blends. With all-latex the acrylate copolymer is stronger than the styrene–butadiene latex, but the reverse is true with the starch-latex blends. The vinyl acetate polymers are all weaker binders with the intermediate copolymer showing somewhat better properties.

Table IV gives the varnish holdout figures for two binder levels; other binder levels were also examined (*6*) but only typical values are reported in this paper. The acrylate copolymer gave consistently the best holdout values with the all-latex systems, but with the starch blends styrene–butadiene was superior, showing the excellent compatibility of the formulation with starch. The vinyl acetate copolymers also show good holdout properties. It should be pointed out that this property is not comparable with different polymers since the swelling power with the xylene varies greatly. However, as will be shown later, the test can give considerable information when used in a series employing the same type of polymeric binder.

Table V gives the gloss readings for both all-latex and starch-latex blends for a wide range of binder levels. The well-known drop-off in gloss with increasing binder level is clearly evident, although it is not as steep in the case of latex binders as with casein or starch, as is the tremendous improvement in gloss brought about by the latex binders. Again, the acrylate and styrene–butadiene are good, although the vinyl acetate copolymers also give excellent gloss values. In general, the

Table IV. Varnish Holdout

Using Various Concentrations of Xylene in Sherwin-Williams Overprint Varnish No. XLB-C26

Polymer	10% Binder All-latex	14% Binder All-latex	14% Binder Starch-latex	18% Binder All-latex	18% Binder Starch-latex
Styrene–butadiene	40.0	60.0	35	75	47.5
Acrylate copolymer	50.0	87.5	25	100	32.5
Polyvinyl acetate	35.0	40.0	25	50	25
Vinyl acetate–dibutyl maleate copolymer 75-25	40.0	85.0	35	90	40
Vinyl acetate–dibutyl maleate copolymer 65-35	57.5	70.0	40	80	40

Table V. Gloss of Coated Papers
Bausch and Lomb Gloss Meter

Polymer	Binder level, % 8 Latex	12 Latex	14 Latex	14 Starch-latex	18 Latex	18 Starch-latex	20 Starch-latex
Styrene–butadiene	73.5	70.3	67.3	54.0	65.5	51.0	46.5
Acrylate copolymer	72.5	68.3	67.5	56.0	64.2	52.5	48.0
Polyvinyl acetate	66.0	59.5	57.8	52.5	51.8	48.5	43.5
Vinyl acetate–dibutyl maleate copolymer 72-25	...	71.0	70.5	53.3	68.0	49.3	46.8
Vinyl acetate–dibutyl maleate copolymer 65-35	69.5	65.5	64.5	54.5	64.8	51.0	47.5

Dried at 90°C. for 1.5 min., calendered 55°C. and 5000 lb./ft.

differences between the latices themselves are not great compared with the effect of binder level and the effect of replacement of starch with latex.

Table VI gives the opacity, brightness, smoothness, and stiffness figures at two comparable binder levels for the all-latex and starch-latex systems. As might be expected the latex used has little effect on the opacity of the coating or on the brightness, except that styrene–butadiene gave somewhat inferior brightness due presumably to its residual unsaturation and oxidizability. The starch-latex blends at the same binder level give somewhat higher opacity and brightness presumably due to the opacity of the free films with the blends. The smoothness of the coatings at the same two comparable binder levels are included in Table VI. The latex confers much greater smoothness to the coatings, styrene–butadiene being outstanding in this respect. The smoothness was also measured at a number of different binder levels without significant differences being observed.

Finally, the stiffness of the samples was measured, typical results are also included in Table VI. The stiffer polymer, polyvinyl acetate, gave much stiffer sheets and in general the stiffness, as would be expected, followed in the order of the stiffness of the free polymer films. The starch blends gave stiffer coatings, except in the case of the stiff polyvinyl acetate homopolymer where a decrease was observed.

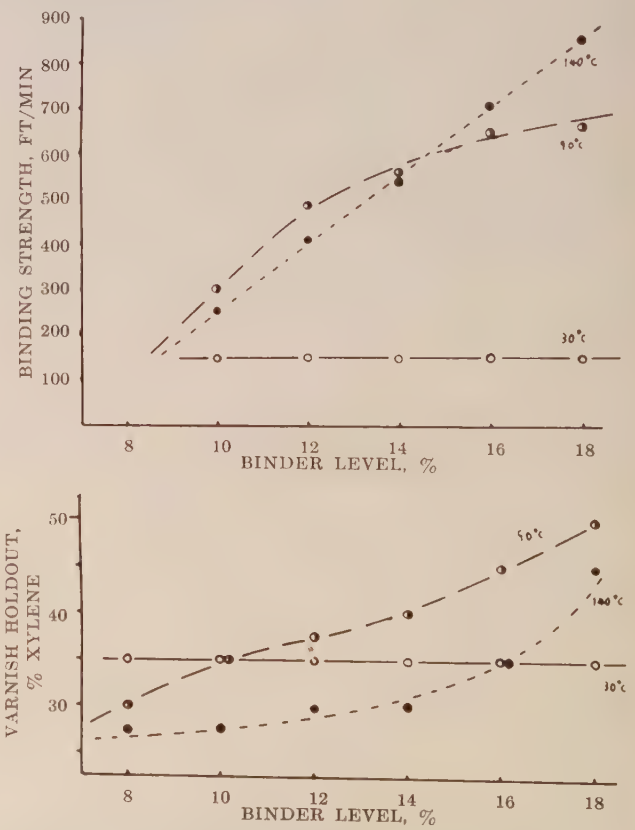
Table VI. Some Properties of the Coated Papers

Polymer →	Styrene–butadiene	Acrylate copolymer	Polyvinyl acetate	Vinyl acetate–dibutyl maleate copolymer 75-25	Vinyl acetate–dibutyl maleate copolymer 65-35
Opacity[a]					
14% All-latex	90.0	91.7	91.7	90.0	90.7
16% Starch-latex	90.5	90.6	91.8	89.5	90.4
Brightness[b]					
14% All-latex	75.7	77.1	77.8	77.2	77.4
16% Starch-latex	76.5	78.0	78.2	77.1	77.7
Smoothness[c]					
14% All-latex	326	260	253	280	246
16% Starch-latex	215	200	190	210	230
Stiffness[d]					
14% All-latex	82.2	90.5	164.3	104.3	94.1
16% Starch-latex	102.2	111.0	128.8	117.7	102.8

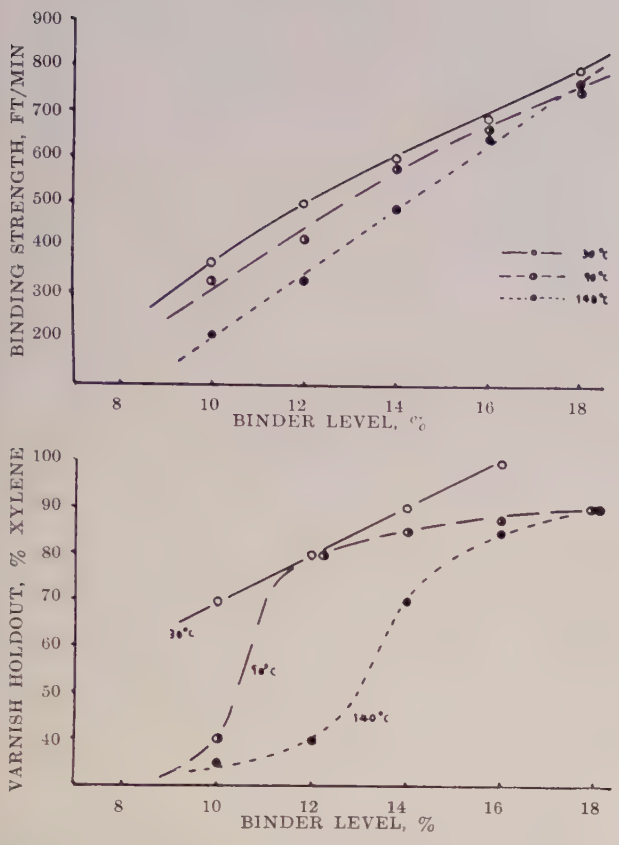
[a] Bausch and Lomb opacity meter.
[b] Hunter multipurpose reflectometer.
[c] Bekk smoothness tester.
[d] Gurley tester.

Effect of Drying Temperature

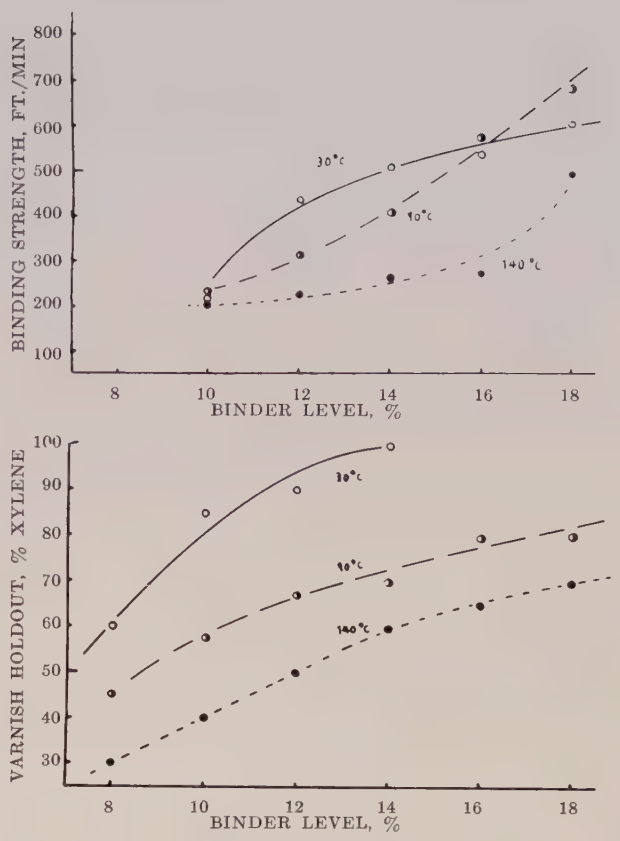
The various results reported above were all obtained with samples dried at 90°C. for 1.5 min. Similar measurements were carried out on samples dried at 30°C. for 3 min. and 140°C. for 1 min. In all cases, the coated sheets were conditioned for 24 hr. before supercalendering. Since all the latices used were thermoplastic, their film-forming properties were dependent on the temperature at which film formation took place. Furthermore, the coating color is a colloidal system consisting of both pigment and polymer particles. At the binder levels commonly used in paper coating the pigment content is above the critical pigment volume concentrations and the major portion of the system is occupied by pigment particles. The distribution of polymer particles and how they form films in the system have therefore considerable significance. If the distribution of polymer is changed, it affects chiefly the binding strength (pick resistance) or the varnish holdout of the coated papers. Figures 1 to 8 show some typical values for these two properties on similar samples dried at different temperatures. The vinyl acetate homopolymer latex gives greatly improved binding strength at higher drying temperatures undoubtedly due to the better film-forming properties of this polymer at higher temperatures, the glass temperature being about 28°C. The other polymers have much lower glass temperatures and consequently the temperature has less effect on their properties.



Figs. 1 and 2. Binding strength and varnish holdout as a function of binder level for vinyl acetate homopolymer latex



Figs. 3 and 4. Binding strength and varnish holdout as a function of binder level for 75–25 vinyl acetate–dibutyl maleate copolymer latex



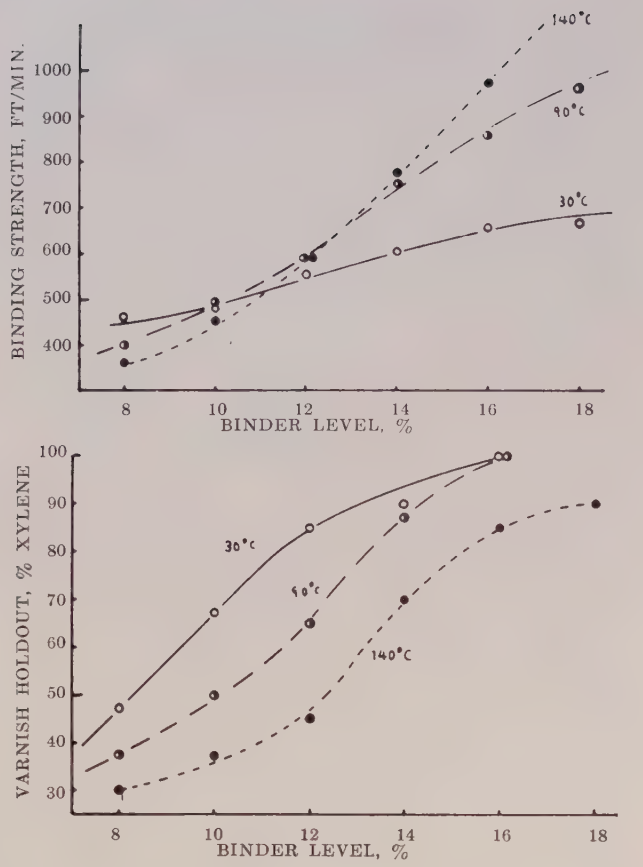
Figs. 5 and 6. Binding strength and varnish holdout as a function of binder level for 65–35 vinyl acetate–dibutyl maleate copolymer latex

The gloss of the all-latex coating decreases with increasing drying temperature even with the vinyl acetate homopolymer; but that of the starch-latex blends was unaffected by temperature. In general, the smoothness was also somewhat higher with the lower temperature cure. These results undoubtedly reflect the changes in the surface contours of the coating as the latex has more opportunity to fuse and flow.

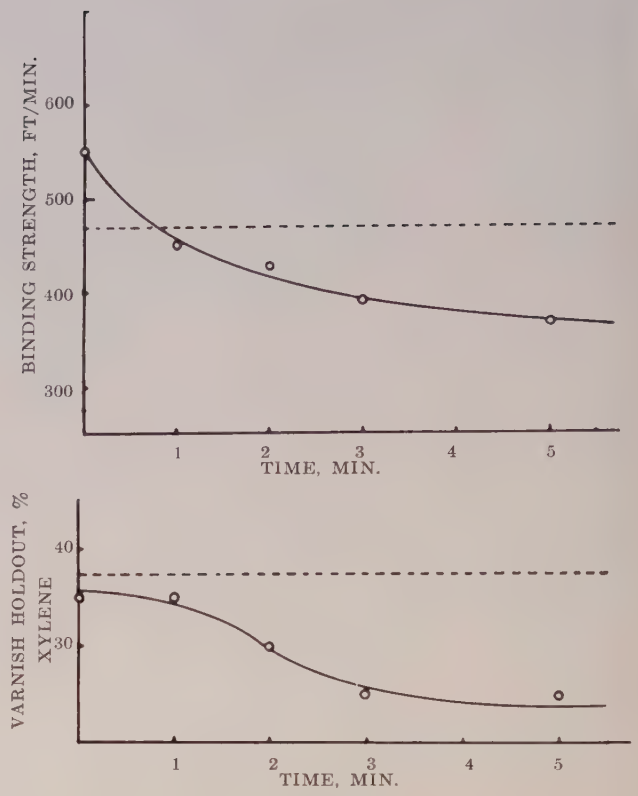
The brightness was not changed by changes in the drying temperature. The drying temperature exerts two main effects which compete with each other: one is the heat-fusing effect on the polymer, and the other is the acceleration of the rate of water removal from the system, which may cause excess penetration of the adhesive into the paper substrate or uneven distribution of the adhesive in the coated paper, depending on the type of paper and the drying method used. If the probability of the polymer particles coming into contact with each other is high, the first effect will be dominant; on the other hand, if this probability is lower, then the second effect would be expected to be operative. The coating color with low binder content in the all-latex and in the starch-latex systems would correspond to the second case. In general, up to a certain binder content the effect of drying temperature on the binding strength would be negative, and after that point the effect would become positive. These relationships are clearly shown for some characteristic cases in Figs. 1 to 8. In the case of the styrene–butadiene latex the same tendencies were found but the effect of temperature was much less pronounced than in the cases illustrated in Figs. 1 to 8. There was a tendency, however, toward somewhat higher binding strength and lower varnish holdout with increasing drying temperature. With the starch-latex blends the effect of the drying temperature on the pick resistance and varnish holdout is much less pronounced However, there is a tendency toward less binding strength and lower varnish holdout at the higher temperatures.

In order to gain more insight into the effects of polymer particle distribution on the coating properties the following experiments were also made. The freshly coated sheets were kept at room temperature without air circulation for 0, 1, 2, 3 and 5 min. before placing in the oven at 140°C. The oven-drying times were 1 min for the sheet put in the oven immediately, 45 sec. for the 1-min. samples, and 40 sec. for the others. One group was dried completely at room temperature. The coating colors were made up at 12% binder since the differences between the varnish holdout values at different drying temperatures were at a maximum at this binder level. The vinyl acetate homopolymer, the 35% dibutyl maleate copolymer, and the acrylate copolymer were used for these experiments since they showed the greatest changes with drying temperature. The binding strength and the varnish holdout values are shown for the various drying conditions in Figs. 9 to 14.

It can be seen that only the vinyl acetate homopolymer latex gave higher binding strength than the sheets dried at room temperature, and showed decreasing strength with increasing time before heating. The varnish holdout results were similar although even the initially heated sheet did not equal the room-temperature dried coating in holdout value. The vinyl acetate copolymer increased in binding strength



Figs. 7 and 8. Binding strength and varnish holdout as a function of binder level for the acrylate cooplymer latex



Figs. 9 and 10. Binding strength and varnish holdout vs. time at room temperature before final drying at 140°C. Polyvinyl acetate latex at 12% binder content. The dotted line represents drying entirely at room temperature.

and holdout with increasing time before heating but never reached the room-temperature values. The acrylate behaved similarly although the binding strength did actually reach, but not exceed, the room temperature value in the case of the sheets which were left 5 min. before heating. The varnish holdout, however, never did reach the room temperature value.

Even after 5-min. drying at room temperature, where the sheet was still moist but the coated surface was almost dry, heating has a remarkable effect on the binding strength and the varnish holdout. This illustrates why the varnish holdout generally decreases when the sheet is dried at high temperatures, even if binding strength is increased by heating. If a coated sheet is dried at high temperature and gives increased binding strength, it is naturally supposed that this is due to better film formation of latex particles at high temperatures, and the sheet must have higher varnish holdout properties than the sheet which was dried at lower temperature; Figs. 1 to 8 shows that just the reverse takes place.

On drying the latex, the temperature at which film formation takes place is one of the most important factors. However, there is another important factor to which less attention has been paid; this is "how" and "how fast" the water is removed from the system, meaning not only temperature changes but other driving forces concerned with drying rate such as circulation of air, and humidity of air in the driers, and the absorbency of the paper substrate. This is a particularly important consideration for the drying of latex-containing pigments, because the coated layer shrinks during the drying. If only latex is present the film is deformable and can follow the shrinkage. If there are pigment particles, however, they cannot follow the shrinkage of system and make for uneven films or cracks in the system.

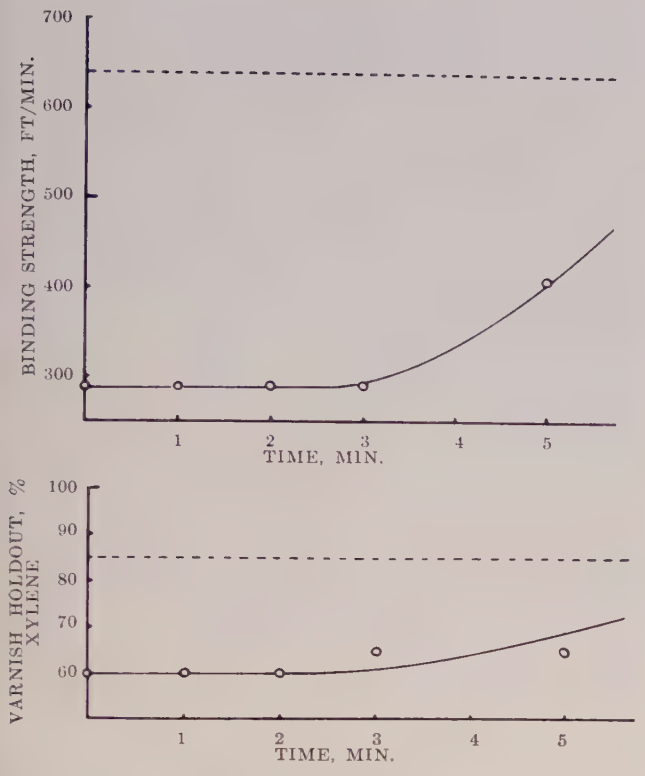
This was also observed in a parallel study of the critical pigment volume concentration when pigment-loaded latex was applied on a glass surface and dried in an air-circulating oven. It was impossible to get films of uniform thickness.

In the case of the vinyl acetate homopolymer latex (Figs. 9 and 10) the resin is film formable at room temperature but the glass temperature is relatively high and plastic flow at room temperature is not enough; therefore the heating effect on film formation is controlling the process. It must also be pointed out that water is a plasticizer for vinyl acetate polymer. These are the reasons why the binding strength and the varnish holdout of this latex decrease as a function of the time before heating.

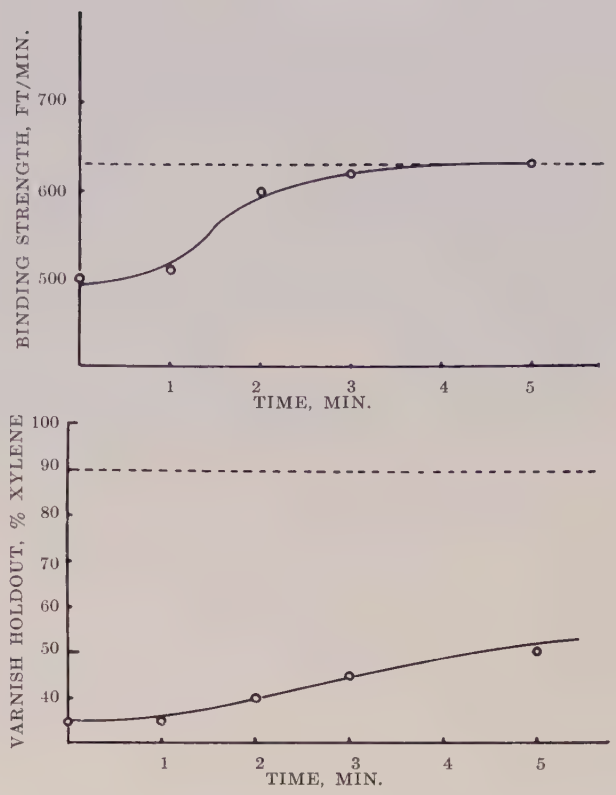
In the case of the vinyl acetate copolymer the flow properties are sufficient and may cause excess flow at high temperatures. As a result, the shrinking effect is exclusive. In the case of the acrylate copolymer latex the result is less time dependent but can be explained in the same way.

It must be taken into account that a relatively low binder level was used. At such a level the heating effect on the binding strength is zero or negative for the latices used in this experiment. At higher binder levels the heating effect usually becomes positive and the difference of varnish holdout due to the heating becomes progressively less. This means that the binder level also must be taken into account when we discuss the effect of drying conditions.

Why the acrylate copolymer latex is less time



Figs. 11 and 12. Binding strength and varnish holdout vs. time at room temperature before final drying at 140°C. Vinyl acetate-dibutyl maleate 65-35 copolymer latex at 12% binder content. The dotted line represents drying entirely at room temperature.



Figs. 13 and 14. Binding strength and varnish holdout vs. time at room temperature before final drying at 140°C. Acrylate copolymer latex at 12% binder level. The dotted line represents drying entirely at room temperature.

dependent than the vinyl acetate copolymer can be explained by the concept of binder level. The densities of the two polymers are 1.15 and 1.09 g./cc., respectively. Consequently the volume concentration of binder is somewhat higher in the acrylate bound coating. The concept of the critical pigment volume concentration of latex, which means how effectively the latex particles cover the pigment surface, is also useful in this consideration. The critical pigment volume concentration of the acrylate is higher than that of the vinyl acetate copolymer (49 and 45%, respectively). Consequently the surface of the pigments was covered more effectively by the polymer particles, and hence the less time dependence.

The Effect of Supercalendering Conditions

In order to compare the ease of supercalendering, coated papers were prepared at the 14% binder level in the case of the all-latex binders and 16% for the starch-latex binders. The samples were dried at 90°C. and conditioned for 24 hr. before supercalendering. Combinations of three different temperatures and three different pressures were used. Tables VII and VIII summarize the effect of supercalendering conditions on the gloss, and Tables IX and X the effect on the smoothness. The differences due to the binder are not great at high temperatures and pressures where the gloss and smoothness are close to the maximum obtainable with the pigment used; but the differences become increasingly greater at lower temperatures and pressures. It becomes easier, therefore, to make comparisons of the ease of supercalendering under mild conditions. The data show that the softer the polymer the easier it is supercalendered. Temperature has a significant role in the supercal-

Table VII. Gloss at Different Supercalendering Conditions
All-latex 14% binder level, dried at 90°C.

Latex	Temperature, °C. 24	55	88
2000 lb./12 in. pressure			
Vinyl acetate	43.5	56.5	64.5
Vinyl acetate–dibutyl maleate 65-35	47.5	63.0	66.0
Styrene–butadiene	56.0	65.0	64.5
Acrylate copolymer	55.0	65.0	67.5
3500 lb./12 in. pressure			
Vinyl acetate	56.0	66.0	68.0
Vinyl acetate–dibutyl maleate 65-35	53.5	69.5	70.0
Styrene–butadiene	59.0	69.0	69.0
Acrylate copolymer	58.5	80.0	71.5
5000 lb./12 in. pressure			
Vinyl acetate	53.0	68.5	70.5
Vinyl acetate–dibutyl maleate 65-35	61.5	72.0	70.5
Styrene–butadiene	64.5	72.0	72.0
Acrylate copolymer	60.0	72.0	72.5

Table VIII. Gloss at Different Supercalendering Condition
50-50 Starch-latex 16% binder level, dried at 90°C.

Latex	Temperature, °C. 24	55	88
2000 lb./12 in. pressure			
Vinyl acetate	33.0	44.5	45.0
Vinyl acetate–dibutyl maleate 65-35	37.0	48.0	49.5
Styrene-butadiene	38.5	46.0	45.0
Acrylate copolymer	40.0	46.0	45.5
3500 lb./12 in. pressure			
Vinyl acetate	38.5	49.0	49.5
Vinyl acetate–dibutyl maleate 65-35	42.5	51.5	51.5
Styrene-butadiene	44.0	51.0	49.5
Acrylate copolymer	42.5	52.0	52.5
5000 lb./12 in. pressure			
Vinyl acetate	42.5	54.5	54.5
Vinyl acetate–dibutyl maleate 65-35	46.0	57.0	58.0
Styrene-butadiene	49.0	57.0	57.0
Acrylate copolymer	48.0	58.0	57.5

Table IX. Smoothness (Sec.) at Different Supercalendering Condition

All-latex 14% binder level, dried at 90°C.

Latex	Temperature, °C. 24	55	88
2000 lb./12 in. pressure			
Vinyl acetate	110	170	160
Vinyl acetate–dibutyl maleate 65-35	110	135	160
Styrene-butadiene	120	150	150
Acrylate copolymer	110	120	190
3500 lb./12 in. pressure			
Vinyl acetate	130	180	200
Vinyl acetate–dibutyl maleate 65-35	150	280	220
Styrene-butadiene	160	220	300
Acrylate copolymer	150	210	290
5000 lb./12 in. pressure			
Vinyl acetate	190	320	290
Vinyl acetate–dibutyl maleate 65-35	180	300	340
Styrene-butadiene	200	310	280
Acrylate copolymer	200	270	330

Table X. Smoothness (Sec.) at Different Supercalendering Condition

50-50 Starch-latex 15% binder level, dried at 90°C.

Latex	Temperature, °C. 24	55	88
2000 lb./12 in. pressure			
Vinyl acetate	90	150	160
Vinyl acetated–dibutyl maleate 65-35	90	185	160
Styrene-butadiene	100	180	220
Acrylate copolymer	80	180	170
3500 lb./12 in. pressure			
Vinyl acetate	140	210	270
Vinyl acetate–dibutyl maleate 65-35	140	210	280
Styrene-butadiene	120	240	280
Acrylate copolymer	120	210	270
5000 lb./12 in. pressure			
Vinyl acetate	180	300	360
Vinyl acetate–dibutyl maleate 65-35	170	280	350
Styrene-butadiene	190	330	330
Acrylate Copolymer	170	300	280

endering of coated papers with latex binders, especially in the case of all-latex binders, and the higher the temperature the easier it is to calender and the less the differences between different latices.

The opacity of the coated papers was found to be higher the harder the polymer and to decrease somewhat as the severity of the supercalendering increased, i.e., with increasing temperature or pressure, or both. The pick resistance of the samples was not greatly affected by changes in supercalendering conditions although somewhat decreased values were found with more severe calendering. These results are, at least partly, due to the decreased roughness of the surface, i.e., a rougher surface may have less contact area when the ink is applied and therefore the shearing stress is less for the rough paper surface.

The varnish holdout was found to increase with increased severity of supercalendering. This is probably due to the increased density of the coated paper. It should be emphasized that all the results discussed in this paper were obtained with hand-coated samples; however, the results were found to be reproducible and we believe that for comparative studies of the type reported such laboratory work is quite satisfactory. It is obvious that such work should be followed up by machine runs for more precise comparisons under operating conditions.

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Solubility of Cellulose in Iron-Sodium Tartrate Solution

CARL J. MALM, R. E. GLEGG, and MARGARET LUCE

A rapid method was developed to determine the percentage of a cellulose which dissolves in iron-sodium tartrate (FeTNa) from transmitted light readings of the solution containing the suspended insoluble fibers. This percentage is influenced by the concentration of free sodium hydroxide and the temperature of the FeTNa solution. Optimum solvent power was obtained at 6% free sodium hydroxide. Solubility increases as the temperature is lowered. When cellulose is treated with increasing concentrations of aqueous sodium hydroxide, followed by washing with water, the solubility in FeTNa decreases. Minimum solubility is reached after treatment with 10 to 14% sodium hydroxide. The degree of solubility also depends on the temperature of the alkali treatment. If the sodium hydroxide is not washed out, the solubility is not changed by alkali treatment. The amount of insoluble material generated by alkali treatment is influenced by the viscosity of the cellulose. The insoluble portion of 15 samples of alkali-treated cellulose decreased from 100% to 17% at 25°C. in FeTNa containing 6% free sodium hydroxide as [η] decreased from 7.5 to 4.7 dl./g. The samples were completedly dissolved for viscosity determination by cooling the solution to 6°C.

This work presents the possibility of determining viscosity distribution of a cellulose by changing the temperature and/or the sodium hydroxide content of a FeTNa solution, the soluble material having lower viscosity than the insoluble fraction.

Cuprietheylenediamine is gradually supplementing cuprammonium as a cellulose solvent for viscosity determinations. However, 16 samples of cellulose out of 22 regenerated from cellulose acetates and propionates were not completely soluble in cuprietheylenediamine at 25°C. On the other hand, these samples were completely soluble at 25°C. in iron-sodium tartrate, a solvent introduced by Jayme and co-workers (*2–4*) and later studied by Valtasaari (*8*).

The use of this solvent was then extended to samples of wood cellulose and it was found that most commercial samples tested were at least 99% soluble at 25°C. A

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few experimental pulps were as much as 70% insoluble, and it was later found that these had been treated with cold alkali during refinement. This led to a study of the effect of sodium hydroxide treatment on solubility of cellulose in iron-sodium tartrate, and included variations in temperature and concentration of alkali. The cellulose samples included regenerated cellulose, wood cellulose, and cotton linters.

The standard solution of iron-sodium tartrate used in this work contains 6% free sodium hydroxide. A set of experiments were carried out to measure the dependence of solubility on the amount of free sodium hydroxide in the solvent. Between 6 and 35°C. the temperature of the iron-sodium tartrate solution also influences the solubility.

The large number of experiments made it necessary to measure the amount of insoluble material by a simpler and faster method than collecting, washing, drying, and weighing the cellulose. An optical method was developed; it involves measuring the amount of light transmitted by the cellulose suspensions in iron-sodium tartrate. Unless otherwise stated solubility was studied at 25°C. in iron-sodium tartrate containing 6% free sodium hydroxide.

EXPERIMENTAL

Preparation of Iron-Sodium Tartrate Solution (FeTNa)

This procedure for preparing one liter of solution is similar to that described by Valtasaari (*8*). As the main modification, 35 g. of sodium tartrate (instead of 5 g.) is used to stabilize the solution. All materials should be reagent grade.

1. Dissolve 99 g. of sodium hydroxide (97% purity) in 250 ml. of distilled water and cool the solution to 6°C.

2. Dissolve 207 g. of sodium tartrate ($Na_2C_4H_4O_6 . 2H_2O$) in 400 ml. of warm distilled water, and cool the solution to 6°C.

3. Dissolve 121 g. of ferric nitrate [$Fe(NO_3)_3 . 9H_2O$] in 160 ml. of distilled water in a 2-liter stainless steel beaker. This salt is hygroscopic and should be weighed quickly just before it is needed.

4. Place a pail with cracked ice around the beaker containing the ferric nitrate solution. Cover the beaker with black sheeting, then add the cold tartrate solution rapidly with vigorous stirring. The intermediate tartrato-ferric acid is light-sensitive. Continue stirring for 3 min.

5. Keeping the temperature below 20°C. at all times, add the cold sodium hydroxide solution very slowly with stirring. After about one half of the sodium hydroxide has been added, the remainder of the alkali may be added rapidly, since it will cause only a slight rise in temperature. Stir for another few minutes.

6. Warm the solution to 25°C., then transfer to a 1-liter volumetric flask with a graduated neck. Estimate the necessary amount of water to bring the volume to 1-liter. Pour the solution back into the beaker and add this amount of water with stirring.

7. Add 35 g. of solid sodium tartrate to stabilize the solution for long periods. Stir until it dissolves.

8. The final solution should be clear and green. If on standing it deposits small amounts of brown ferric hydroxide, filter through a sintered glass funnel. The solution can be stored at 25°C. for months without special protection from air or ordinary room lighting. Four-liter batches can be prepared conveniently by using proportionate amounts of reagents.

In this preparation 0.9 mole of sodium hydroxide is required to react with 0.3 mole of iron; this leaves 1.5 moles per liter (6% by volume) of free sodium hydroxide in the iron-sodium tartrate solution. This is the standard solvent used in this work unless otherwise specified.

In one series of experiments the solubility of cellulose was measured in iron-sodium tartrate containing 0 to 16% free sodium hydroxide. To increase the free NaOH, an appropriate amount of solid sodium hydroxide was added to a known volume of the standard FeTNa with stirring, keeping the temperature below 25°C. until the alkali dissolved. For example, to prepare FeTNa with 16% free NaOH, 10 g. of sodium hydroxide was added per 100 ml. of standard FeTNa. To decrease the free NaOH, the required amount was deducted while preparing a new solution.

Sources of Cellulose

A large part of this paper deals with the effect of alkali treatment on the solubility of cellulose in FeTNa. Bleached cotton linters from three sources were 70 to 90% insoluble without alkali treatment and will not be discussed further in this connection.

Cellulose was regenerated from cellulose esters with 0.5 *N* sodium methylate in methanol (*6*) or with 14% ammonium hydroxide. In some cases the ester was treated with sodium hydroxide directly, and this also removed the acyl groups.

Four commercial sulfite wood pulps were chosen to cover a range of alpha-cellulose and intrinsic viscosity (Table I).

Alkali Treatment of Cellulose

1. Slurry the cellulose in distilled water, then centrifuge. Weigh out enough of the wet sample to correspond to 50 g. of dry cellulose, and add it to 1200 ml. of sodium hydroxide solution. The alkali solution should be strong enough so that the water adhering to the cellulose dilutes it to the desired concentration (grams NaOH as a percentage of the total weight of alkali solution).

2. Leave the cellulose in the alkali solution for 1 hr. at the appropriate temperature, and stir every 15 min.

3. Remove the alkali by suction on a Buchner funnel, and soak the pulp in several changes of distilled water until the pH of the wash water is less than 9.

4. Soak the cellulose for 1 hr. at 20°C. in 800 ml. of distilled water containing 0.15% sulfur dioxide.

5. Wash repeatedly in distilled water until the pH is 5 to 6. Squeeze the sample to remove the bulk of the water. Moisture contents of the alkali-treated cellulose samples were 50 to 70%. Most solubility studies were made with these wet samples, but in some cases they were air-dried at room temperature for four days and then for 3 hr. at 60°C. *in vacuo*.

Quantitative Determination of Cellulose Insoluble in FeTNa

The starting solutions contained 0.2% cellulose by weight in iron-sodium tartrate solvent, and the amount of insoluble material was measured after shaking for 16 hr. at the desired temperature. Turbidity measure-

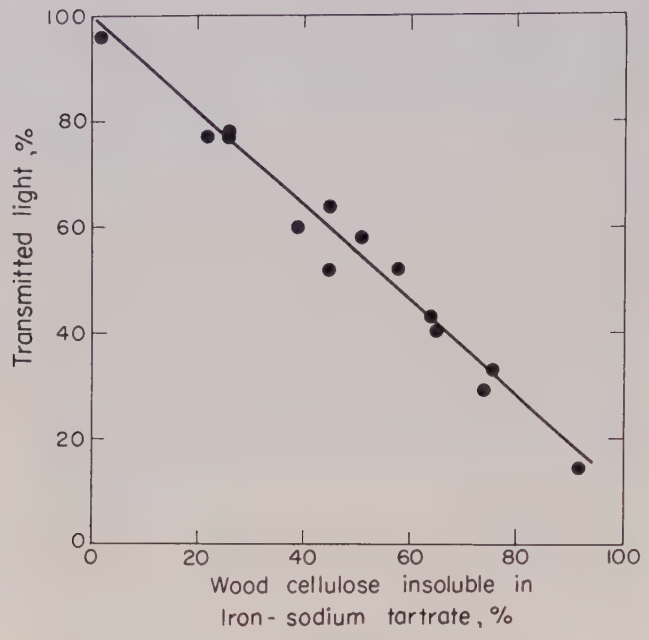

Fig. 1. Calibration curve

ments on the cellulose suspensions were calibrated against the amount of insoluble material found by weighing. This gave a calibration curve which was used for routine determinations.

One gram of pulp is added to 500 ml. of FeTNa and, after shaking, the insoluble portion is centrifuged to a compact mass. Most of the supernatant liquid is decanted through a sintered-glass funnel without disturbing the precipitate. The residue is transferred to the funnel and the adhering FeTNa sucked off under vacuum. Small amounts of cellulose are washed out of the centrifuge bottle with 1:10 glycerol–water (*2*) and combined with the residue on the filter. The cellulose is washed with glycerol–water until the green color of FeTNa disappears, then six times with 25-ml. portions of 1% acetic acid, six times with distilled water, three times with methyl alcohol, and finally with acetone. The insoluble residue is dried for 1 hr. at 50°C., then 1 hr. at 110°C., and weighed.

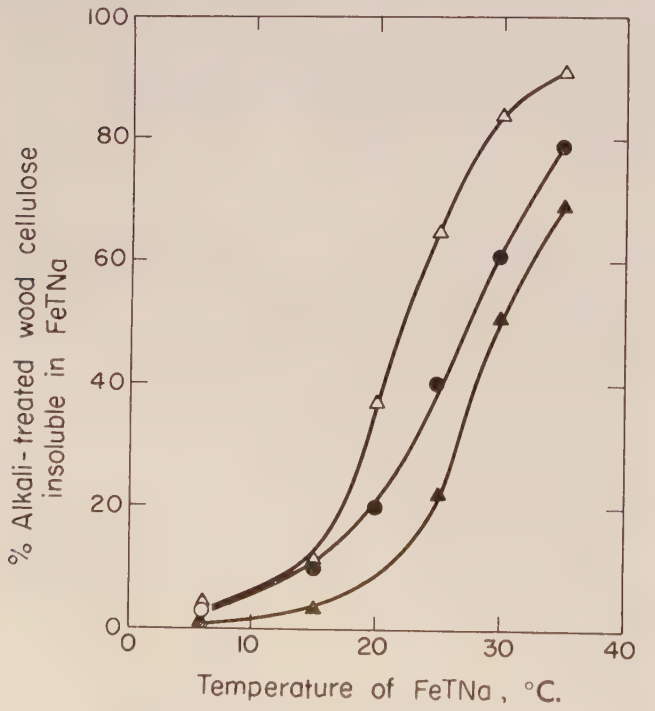

Fig. 2. Effect of temperature of FeTNa solution on the solubility of alkali-treated cellulose
△ Cellulose B, 10% NaOH at 20°C.; ● Cellulose C, 10% NaOH at 20°C.; ▲ Cellulose B, 8% NaOH at 20°C.

Turbidity measurements were made with a transmitted light meter previously described by Malm, *et al.*, for measuring the reactivity of cellulose (*5*). A photoelectric cell, placed in the center of the light path, is connected to a Weston microammeter. There is no polarizing analyzer in the transmitted light path.

A weight of 40 mg. of cellulose on a dry basis is shaken in a 25-ml. volumetric flask with 20 ml. of FeTNa. Just before making a measurement the flask is slowly swirled several times to completely suspend the insoluble particles. This is done gently to avoid forming air bubbles, which would give a slightly lower transmitted light reading. The suspension is then carefully transferred to a 20-mm. rectangular glass cell (Will Corp. No. 9091) to measure the amount of transmitted light. The instrument is previously adjusted to read 100 on the transmitted light scale with a sample of the FeTNa solvent in the light path. In this way the readings are expressed as a percentage of transmitted light.

Figure 1 is a calibration curve for four sulfite pulps which had been alkali-treated under varying conditions of sodium hydroxide concentration and temperature.

RESULTS AND DISCUSSION

Effect of Temperature of FeTNa Solution on Solubility of Alkali-Treated Cellulose

Figure 2 shows that as the temperature of the FeTNa solution is increased, the solubility of alkali-treated cellulose decreases. All samples of cellulose so far encountered are almost completely soluble in FeTNa at 6°C., regardless of their previous history.

If a sample is shaken first at 35°C., then at 30°C., and finally at 25°C., the amount of insoluble material is the same as for a sample shaken at 25°C. only. When a sample has dissolved at 6°C., it does not come out of solution when the temperature is raised to 25°C., even if it was originally insoluble at 25°C. This is fortunate, since samples can be dissolved at the lower temperature and then warmed for viscosity determination at 25°C.

Effect of Temperature and Concentration of Alkali Used in Cellulose Treatment on Solubility in FeTNa

Samples were prepared from cellulose sample C (Tabel I), by treating with 6 to 18% sodium hydroxide at temperatures ranging from −15° to 100°C.

Temperature of NaOH. Figure 3 shows that as the temperature of the sodium hydroxide is raised, the amount of cellulose C insoluble in FeTNa decreases. This effect is more pronounced at the lower alkali concentrations.

Concentration of NaOH. At any given temperature (Fig. 3) the concentration of sodium hydroxide determines the amount of FeTNa-insoluble wood cellulose C. The insolubility increases with an increase in alkali concentration, reaching a maximum above 10% NaOH.

Alkali treatment affects solubility in cadmium-ethylenediamine in a similar manner. Related observations have been reported for cupriethylenediamine (*1*).

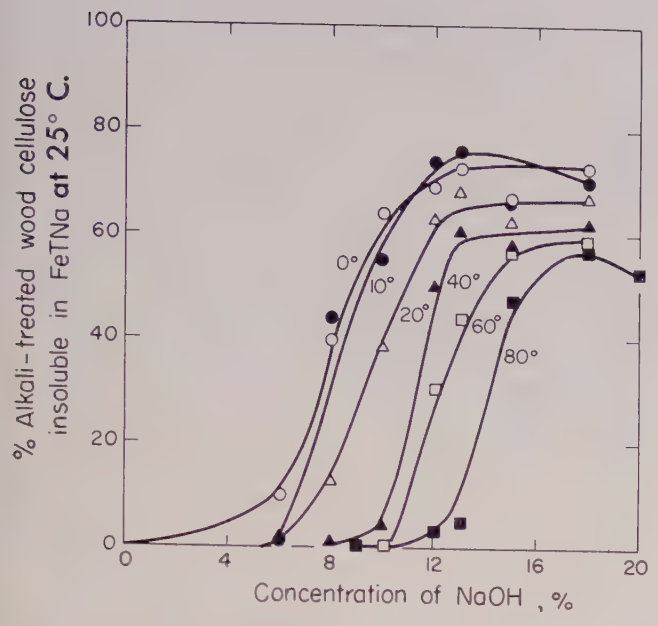

Fig. 3. Effect of temperature and concentration of alkali used in the treatment of wood cellulose C on its solubility in FeTNa

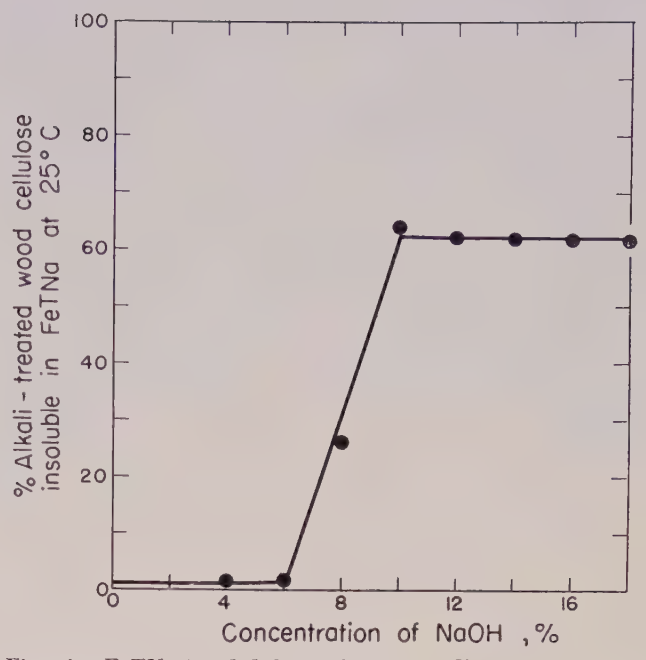

Fig. 4. FeTNa-insolubility of wood cellulose B alkali-treated at 20°C

Influence of Type of Cellulose on FeTNa-Insolubility Generated by Alkali Treatment

Wood Cellulose. Figure 4 shows that with cellulose sample B, which was treated at 20°C., the maximum insolubility is reached with 10% sodium hydroxide rather than with 13%, as in the case of cellulose C (Fig. 3). This difference between the two samples led to further study of other wood celluloses.

Four commercial samples of sulfite pulps were treated at 20°C. with 4 to 18% sodium hydroxide (Table II). Maximum insolubility first appears at different sodium hydroxide concentrations—10% for cellulose A and cellulose B, 12% for cellulose C, and 14% for cellulose D. In addition, maximum insolubility is least for cellulose A, higher for cellulose B and C, which are equally insoluble, and greatest for cellulose D.

These differences may be due to the original cellulose fibers in the various types of wood as well as to changes brought about by the methods of processing. Later it will be shown that there may also be a relationship between solubility and viscosity (or molecular weight distribution). In any case, the results show that it is not possible to quantitatively predict the effect of alkali treatment on solubility.

Regenerated Cellulose. Three different types of regenerated cellulose were used to see if the alkali treatment had the same effect as on wood cellulose.

1. Cellulose was regenerated from a cellulose acetate with 14% ammonium hydroxide. The cellulose was in solution during the acetylation but not during the regeneration.

2. The second cellulose was a sample of water-washed cellophane.

3. A fibrous triacetate was regenerated with sodium methylate in anhydrous methanol. No solution process was involved during the acetylation or regeneration.

When treated with 10% sodium hydroxide at 20°C. and washed free of alkali, they were all soluble in FeTNa at 25°C.

Relationship Between Viscosity and FeTNa Solubility After Alkali Treatment

The results just described for the regenerated cellulose could have been due to the relatively low intrinsic viscosities of the samples—1.2, 1.5, and 3.7 dl./g., respectively. The following experiments were designed to study this point, using some samples available from another investigation.

A series of partly acetylated samples were made by fibrous acetylation of a wood cellulose, so that as the acetyl increased from 7 to 38%, the viscosities gradually decreased (Fig. 5). These samples were treated with 14% sodium hydroxide at 20°C. for 1 hr., and this completely deacetylated the samples. In this case the original wood cellulose (which was a hemlock kraft pulp) was 100% insoluble after alkali treatment.

The solubilities of the alkali-treated regenerated samples were measured in FeTNa at 25°C. (Fig. 6). The amount of insoluble material decreased as the intrinsic viscosity decreased from 7.5 (the alkali-

Table I. Analyses of Cellulose Used in Solubility Studies

	Wood cellulose[a]			
	A	*B*	*C*	*D*
α-Cellulose, %	87.9	93.4	96.9	87.1
Pentosan, %	7.07	2.50	1.50	7.63
Copper no.	2.11	0.45	1.15	1.42
[η] in FeTNa, dl./g.	4.8	8.4	8.9	7.6
Type of wood	Hard	Soft	Soft	Hard

[a] All were commercial samples prepared by the sulfite process.

Table II. Insolubility in FeTNa After Alkali Treatment

Wood Cellulose → *% NaOH at 20°C.*	*% Insoluble in FeTNa at 25°C.* *A*	*B*	*C*	*D*
No treatment	0	0	0	0
4	0	2	0	. . .
6	0	3	0	. . .
8	6	26	13	2
10	27	64	39	51
12	28	62	63	62
14	29	62	66	82
16	22	59	63	82
18	30	62	67	82
[η] in FeTNa, dl./g.	4.8	8.4	8.9	7.6

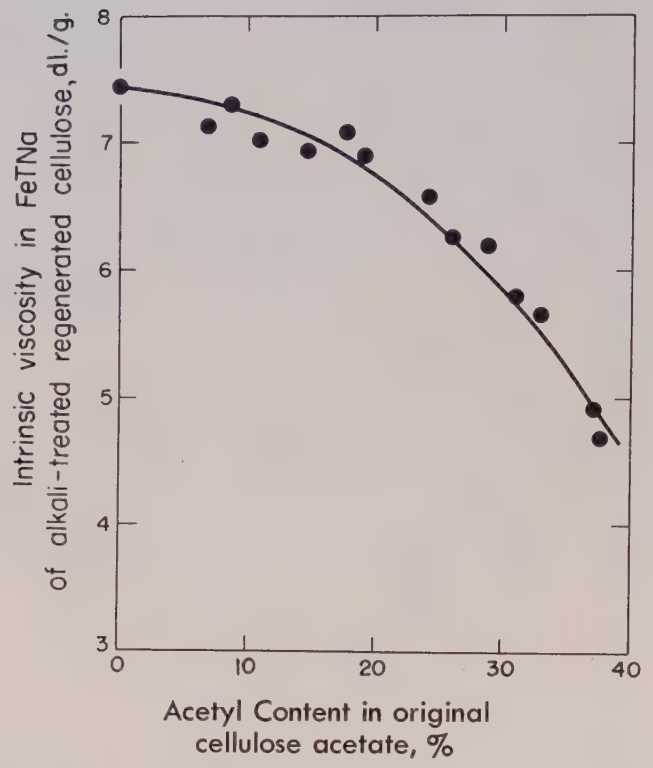
Intrinsic viscosity in FeTNa
of alkali-treated regenerated cellulose, dl./g.
Acetyl Content in original
cellulose acetate, %

Fig. 5. Acetyl content of cellulose acetates and intrinsic viscosity of corresponding regenerated celluloses used in solubility studies

treated wood cellulose) to 4.6 dl./g. This partly confirmed the idea that the effect of alkali treatment of cellulose on solubility in FeTNa depends on the viscosity of the cellulose.

It was still possible that the varying amounts of acetyl may have influenced the effect of treatment with sodium hydroxide. The following experiment excluded this possibility. Whether the starting material was the partly acetylated sample (21% acetyl) or cellulose regenerated from it with sodium methylate, sodium hydroxide treatment produced similar amounts of FeTNa-insoluble material (Table III).

Finally, when wood cellulose was treated with sodium hydroxide before introducing various amounts of acetyl, the insolubilities of the products also decreased with a decrease in viscosity.

The following summary shows that the average viscosity of the sample may be affecting its solubility *after alkali treatment.*

1. Wood pulps in the higher intrinsic viscosity range (7 to 9 dl./g.), such as cellulose B, C, D, and the hemlock kraft pulp can be made as much as 60 to 100% insoluble by alkali treatment (Table II, Fig. 6).

2. A sample of lower intrinsic viscosity such as cellulose A (4.8 dl./g.) can only be made 30% insoluble by the same alkali treatment (Table II).

3. In the case of an alkali-treated cellulose regenerated from a series of partially acetylated fibers, as the intrinsic viscosity decreased from 7.5 to 4.6 dl./g. (Fig. 6), the insoluble portion decreased from 100 to 18%.

Table III. Insoluble Material Produced when Cellulose Acetate or Regenerated Cellulose Is Treated with NaOH

% NaOH at 20°C.	*% Cellulose insoluble in FeTNa*	
	Original acetate[a]	*Regenerated cellulose*
10	62	68
12	62	64
14	58	66

[a] The original material contained 21% acetyl, which was completely saponified by the sodium hydroxide.

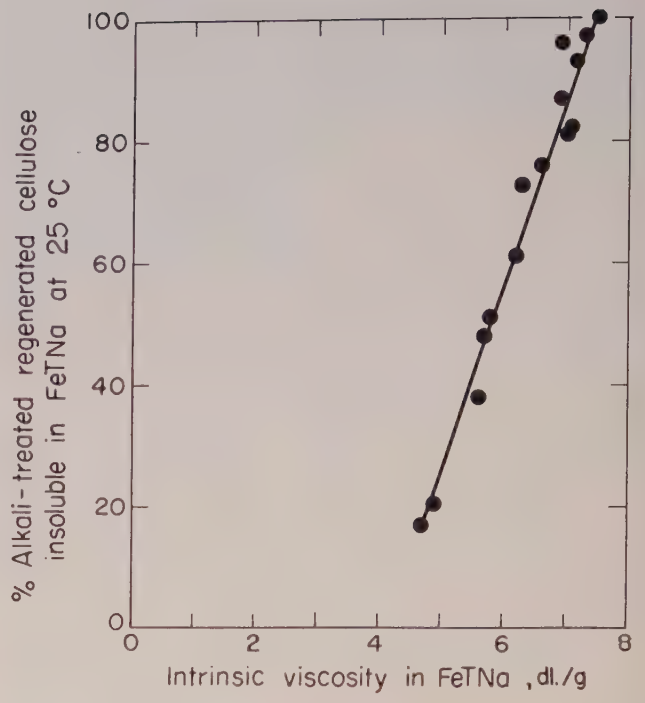

Fig. 6. Relationship between viscosity and FeTNa solubility after alkali treatment

4. Various other types of regenerated cellulose with intrinsic viscosities between 1.2 and 3.7 dl./g. are completely soluble after alkali treatment. It seems that below a certain average viscosity alkali treatment does not make the sample insoluble.

Once a cellulose sample is made partially insoluble by sodium hydroxide treatment, the average viscosity of the soluble portion is lower than that of the insoluble fraction. This point is illustrated without considering the amounts of the various fractions (Table IV). These results suggest that *viscosity distribution* also influences the solubility. Other work shows that it may be possible to fractionate cellulose according to chain length by leaching out the soluble fractions at different temperatures.

Effect of Varying Amounts of Free NaOH in FeTNa on Solubility

The standard FeTNa solution used in this study contains 6% free NaOH by volume; this amount can be either increased by dissolving additional amounts of sodium hydroxide in the regular solution or decreased by using less sodium hydroxide than recommended in the

Table IV. Relationship Between Viscosity of Soluble and Insoluble Fractions

Cellulose C

Alkali treatment		*Intrinsic viscosity (dl./g.) in FeTNa of fraction*	
% NaOH	*Temp., °C.*	*Soluble at 20°C.*	*Insoluble at 20°C.*
13	1	3.6	13.1
18	20	3.9	13.7
18	0	3.9	12.8
13	18	4.3	12.3
18	10	4.6	13.4
13	42	4.9	14.1
13	59	7.7	12.4

Table V. Effect of Free NaOH in FeTNa on Cellulose Solubility

Free NaOH in FeTNa, %	% Cellulose insoluble in FeTNa at 25°C. — Wood cellulose			NaOH treated[a]			Cotton linters
	A	B	C	A	B	C	
0	[b]	[b]	92	..	..	..	97
4	7	9	1	79	94	89	97
5	4	7	1	45	84	79	94
6	2	2	1	24	65	63	74
8	3	2[b]	2	8	24	24	10
10	3[b]	7[b]	2[b]	3	6	9	4[b]
12	7[b]	7[b]	7[b]	7	3	7	6[b]
13	7	15	15	3	8	17	15
14.4	5	39	37	23	44	55	[b]
16	39	65	60	49	74	74	[b]

[a] The wood cellulose received the standard treatment with 12% NaOH at 20°C.
[b] Fibers were not evenly distributed through the solution, but formed balls.

standard procedure. The influence of NaOH concentration in FeTNa was studied at 25°C.

Table V shows that untreated and alkali-treated wood cellulose as well as a sample of bleached cotton linters give a similar result. At the lower concentrations of sodium hydroxide the insoluble portion first decreases with an increase in free alkali, then at a certain concentration the samples become almost completely soluble; as the sodium hydroxide concentration is increased beyond this point the cellulose becomes increasingly insoluble.

For each sample of cellulose a sodium hydroxide concentration is reached at which it dissolves most. This could be useful, alternately or in combination with lowering the temperature of the FeTNa, for dissolving cellulose.

It may be possible to fractionate cellulose according to chain length by dissolving portions with FeTNa containing various amounts of free NaOH. This seems especially attractive in the case of cotton linters, where the insoluble portion of the sample changed from 74 to 10% as the free NaOH was increased from 6 to 8% (Table V).

It is possible that above a certain concentration of free NaOH in the FeTNa, solubility is poorer because of a salting-out effect. There may also be a mass action effect, so that the high concentration of sodium hydroxide prevents formation of the cellulose-FeTNa complex.

No Difference Between Solubility of Wet and Dry Samples

At first it seemed surprising that there was no difference between the solubilities of wet and dry alkali-treated samples (Table VI), since most of the physical and chemical properties of cellulose change on drying. But this fact suggests that the solubility is not dependent on penetration of the iron-sodium tartrate into the collapsed structure that results from drying.

Relationship Between Internal Volume and Solubility

There is consistent evidence that a large internal volume of the cellulose corresponds with greater insolubility. The internal volume can be measured by the amount of benzene which is retained by the cellulose after centrifuging under standard conditions (*9*). The amount of benzene is calculated as a percentage of the original amount of dry cellulose.

There have been numerous examples with wood cellulose taken at various stages of the refinement process and after a wide range of alkali treatment. Higher benzene retention corresponds with greater insolubility in iron-sodium tartrate.

Table VI. FeTNa-Insolubility of Wet and Dry Alkali-Treated Cellulose C

Treatment — % NaOH	Treatment — Temp., °C.	% FeTNa-Insoluble at 25°C. — Wet	Dry
6	−14	30	40
6	−3	8	8
8	2	41	44
8	10	44	46
8	19	13	8
10	−3	66	67
10	11	54	57
12	3	70	73
12	20	63	57
12	40	48	43
12	60	27	26
13	1	73	73
13	11	76	72
13	18	69	69
13	42	60	61
13	59	44	44
13	77	12	6
15	2	67	71
15	9	66	72
15	20	63	71
15	40	58	64
15	60	58	61
15	81	46	45
18	1	73	73
18	10	71	73
18	20	67	69
18	40	57	55
18	62	56	61
20	80	51	57

A reasonable explanation is required for the fact that alkali-treated pulps show different solubilities in FeTNa from the untreated pulps. Present possibilities include permanent changes in the structure of the cellulose, such as internal volume, the ratio of cellulose I to cellulose II, the sizes and distribution of crystallites, aggregation of microfibrils, rearrangement of cohesive bonds such as could be caused by compression of the cellulose molecules during the swelling process, the configuration of the macromolecules after twisting or rotation of glucose units about the glycosidic bonds (*7*), or the formation of mechanical barriers.

There can be little doubt that the various factors contributing to insolubility of alkali-treated samples are related to the amount of sodium hydroxide originally absorbed by the cellulose. When wood cellulose is treated first with 10% NaOH at 38°C., the amount of insoluble material is not reduced by replacing the alkali with successively weaker solutions such as 7 and 4% at 38°C. or with 1% NaOH at 145°C.

All published work shows that alkali absorption by cellulose increases to a maximum with increasing NaOH concentration; the effect of alkali on insolubility in FeTNa follows a similar pattern. Depending on the type of wood cellulose, maximum insolubility of 30 to 100% is reached after treatment with 10 to 14% sodium hydroxide at 20°C.

The structural changes are caused by the alkali, but this influenced solubility only when the absorbed alkali was washed out. If excess alkali is not washed out, only squeezed out, the cellulose is soluble.

Insolubility can be avoided by:

1. Reducing the temperature of a FeTNa solution containing 6% free sodium hydroxide (Fig. 2).

2. Changing the solvent composition so that there is more free alkali (Table V). The exact amount will depend on the original alkali treatment.

Conversely, greater insolubility can be induced in any FeTNa solution by raising the temperature (Fig. 2) or by using a solvent with smaller amounts of free sodium hydroxide (Table V).

The present hope is that with further study along these lines we may learn a little more about the structure of cellulose. One of the most challenging aspects of the work is the possibility of fractionating cellulose in iron-sodium tartrate. It may be possible to do this by varying the temperature and composition of the solvent.

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Structural Board from Domestic Timber Bamboo—*Phyllostachys bambusoides*

T. R. NAFFZIGER, T. F. CLARK, and I. A. WOLFF

Dry, mature timber bamboo was investigated as a raw material for the preparation of insulating and hardboards by several selected pulping techniques. Results of small-scale pulping studies with caustic soda, kraft chemicals, neutral sulfite, lime, and combinations of lime and caustic soda suggested that pulping with lime alone was adequate and that this method merited more detailed investigation for the preparation of rapid- and slow-draining pulps to be used in board furnishes. A series of experiments to prepare structural boards from bamboo pulped with 6, 9, and 12% lime at 142°C. for 1, 3.5, and 6 hr. was then conducted to substantiate preliminary findings and to establish preferred conditions for preparation of boards. Yields of pulp ranged from 83 to 94%; shorter cooking periods favored higher yields. Differences in strength characteristics of either insulating or hardboards could not be related to the amount of lime used since free lime was present at the end of digestions. For insulating boards 70 : 30 blends of rapid- and slow-drain-pulps gave products having strength properties equal to those of commercial boards examined or exceeded them. Experimental hardboards (80 : 20 blends) had values for modulus of rupture and tensile strength comparable to those for standard commercial boards. Impact strengths exceeded those of the commercial controls. Both experimental insulating and hardboards exhibited a high degree of flexibility and had a greater deflection at point of rupture than commercial boards. These experiments have demonstrated that, technically, timber bamboo can be processed with an inexpensive chemical by customary techniques to prepare insulating and hardboards competitive strengthwise with similar commercial products from wood or sugarcane bagasse.

Use of fibrous insulating board and hardboard as materials of construction continues to expand. In 1959 more than 3.0 billion sq. ft. of insulating board ($^1/_2$-in. basis), and 2.0 billion sq. ft. of hardboard ($^1/_8$-in. basis) were produced in the United States (*1*). These figures represent increases over production for the previous year of about 6 and 19%, respectively. In addition, particle board in its first 15 yr. of production grew to more than 0.18 billion sq. ft. ($^3/_4$-in. basis) in 1958 (*2*). Such data support the prediction of the Stanford Research Institute that the consumption of structural fiberboard in the United States will increase threefold between 1953 and 1975, with emphasis on increased hardboard usage (*3*). As labor costs for building construction rise, insulating board panels as sheathing become more economical than conventional wood sheathing. This use warrants increased production of fibrous insulating board. Expansion in the production of structural boards should provide an opportunity for introduction of new fibrous raw materials. Domestically grown timber bamboo, a fast producer of cellulose, offers potential as a raw material for structural boards.

Probably the first published suggestion that bamboos be considered as raw materials for pulping in the United States was made by R. A. McClure, an agricultural explorer of the U. S. Dept. of Agr., who speculated on the future of bamboos for such purposes (*4*). The Department's interest in bamboos is evident from research contracts negotiated between the Plant Introduction Section, Crops Research Division, and the Herty Foundation Laboratory to evaluate a number of bamboos in papermaking (*5*), by the research project conducted by the Northern Laboratory to prepare viscose-grade dissolving pulps from *Phyllostachys bambusoides* (*6*), and by the present investigation to produce insulating boards and hardboards from *Phyllostachys bambusoides*.

Little information has been published concerning preparation of structural boards from bamboo. Between 1945 and 1956, Narayanamurti used *Bambusa polymorpha* to make dense hardboards, but these were weaker than the usual hardboard made from wood in the United States (*7, 8, 9*). One type of hardboard consisted of woven strips of bamboo bonded by a phenolic resin. Methods for manufacture of insulating boards from woods and sugar cane bagasse in the United States are well established (*10*). Hardboard production

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Table I. Conditions for Preparation of Bamboo Pulps, Their Use of Insulating Board Compositions, and Properties of Resulting 1/2-in. Boards

Rapid-draining pulp						Slow-draining (hydrated) pulpa							Board properties			
NaOH, %	CaO, %	Temp., °C.	Time, hr.	Yield, %	Amount used, %	NaOH, %	CaO, %	Temp., °C.	Time, hr.	Yield, %	Freeness, S.-R., ml.	Amount used, %	Density, lb./cu. ft.	Modulus of rupture, p.s.i.	Tensile strength, p.s.i.	Impact strength, ft. lb./sq. in.
9.0	...	143	2	73	100	...	...	...	...	...	...	...	15.3	20	20	0.27
6.0	...	173	2	69	100	...	...	...	...	...	...	...	15.7	40	60	0.54
12.0	...	173	2	59	100	...	...	...	...	...	...	...	17.2	50	70	0.57
...	6.0	173	2	74	100	...	...	...	...	...	...	...	20.1	90	90	0.42
...	6.0	142	1.25	81	100	...	...	...	...	...	...	...	16.2	220	190	0.71
...	12.0	142	1.0	88	100	...	...	...	...	...	...	...	18.6	250	210	0.98
...	6.0	142	1.25	89	90	1.65	6.5	142	5	82	360	10	16.5	190	170	0.76
...	6.0	142	1.25	89	80	1.65	6.5	142	5	82	360	20	17.6	270	240	1.05
...	6.0	142	1.25	89	70	1.65	6.5	142	5	82	360	30	21.4	580	400	1.45
...	6.0	142	1.25	89	70	3.0	12.0	142	5	87	335	30	20.6	250	480	1.78
...	6.0	142	1.25	89	70	1.5	12.0	142	5	85	385	30	21.7	550	450	1.81
...	12.0	142	1.0	88	70	...	12.0	142	1	88	310	30	17.5	370	350	0.97
1.5	12.0	142	5.0	85	70	1.5	12.0	142	5	85	385	30	21.0	480	340	1.65
2.0	8.0	170	5.0	78	70	13.2	6.6[b]	130	2	57	...	30	22.5	540	480	2.73
Commercial boards: 6 brands													18.5–19.5	250–400	170–280	0.6–1.5

[a] Developed by beater refining.
[b] Sodium sulfide.

depends almost entirely on wood; particle boards use wastes and residues from forest products manufacture, as well as from furniture and millwork factories (*11*).

The present report concerns investigations made in two phases: (I) A small-scale study to determine the relative effectiveness of several chemicals in pulping *Phyllostachys bambusoides* as a basis for selecting an appropriate chemical or combination of chemicals to use in phase II; and (II) a detailed study with sufficient time to establish pulping conditions and to develop effective techniques on how to use the pulps in producing insulating boards and hardboards.

EXPERIMENTAL

Culms of *Phyllostachys bambusoides* were obtained from the Department's Barbour Lathrop Plant Introduction Gardens, Savannah, Ga., in the spring of 1957. These culms were from a random harvest late in 1956 and ranged up to 15 yr. of age. After receipt at the Northern Laboratory the culms were stored out of doors without cover for 18 months before use.

Bamboo chips were produced by using a 24-in. diameter 2-knife chipper ordinarily used in the pulping industry. Chips for the small-scale or phase I investigation were used as produced by the chipper without classification and, consequently, included some slivers and segments 2 to 3 in. in length. For phase II studies the chips were screened and that fraction accumulating between the screens having openings of 0.095 and 0.75-in. diameter was recovered for pulping. This fraction, amounting to about 90% of the bamboo, still contained some slivers and particles in lengths appreciably greater than the dimensions of the larger screen. For comparison purposes strength properties of six commerical insulating boards and four commercial hardboards were determined.

Investigations with Various Chemicals

Initial investigations included preparation of pulps by semichemical, mechanochemical, and conventional pressure pulping techniques; the third was the most effective and was selected for the investigation.

In phase I a small globe rotary digester that could accommodate a 3-lb. charge of airdry chips was used. Pulping chemicals included the following: (1) Kraft (caustic soda, 2 parts; sodium sulfide, 1 part); (2) neutral sulfite (sodium sulfite, 2.7 parts; sodium carbonate, 1 part); (3) caustic soda; (4) lime; and (5) combinations of caustic soda and lime. Digestions were made with the amount of chemical ranging up to 20% (basis dry chips) in some instances, at temperatures ranging from 20 to 173°C., and for periods of 1 to 5 hr. Not all combinations of the variables were applied. In all instances the liquid-solids ratio was 6:1.

Digested chips were washed essentially free of pulping chemical and then defiberized in a water-stream in

Table II. Conditions for Preparation of Bamboo Pulps, Their Use in Hardboard Compositions; and Properties of resulting 1/8-in. Boards

Rapid-draining pulp						Slow-draining(hydrated) pulp[a]							Board properties			
NaOH, %	CaO, %	Temp., °C.	Time, hr.	Yield, %	Amount used, %	NaOH, %	CaO, %	Temp., °C.	Time, hr.	Yield, %	Freeness, S.-R., ml.	Amount used, %	Density, lb. cu. ft.	Modulus of rupture, p.s.i.	Tensile strength, p.s.i.	Impact strength, ft. lb./sq. in.
6.0	...	166	2.0	76	100	...	...	...	...	...	...	...	67.6	6390	5380	8.2
9.0	...	143	2.0	73	100	...	...	...	...	...	...	...	63.0	2950	3150	7.4
9.0	...	173	3.0	66	100	...	...	...	...	...	...	...	66.9	5210	8190	9.4
...	6.0	173	2.0	74	100	...	...	...	...	...	...	...	65.6	5350	2650	6.1
...	6.0	142	2.0	84	100	...	...	...	...	...	...	...	61.8	4140	3530	4.7
...	12.0	142	1.0	88	100	...	...	...	...	...	...	...	63.3	5460	4330	4.6
...	12.0	142	1.0	88	80	...	12.0	142	1.0	88	310	20	58.8	4510	4230	3.3
...	6.0	142	1.25	87	70	1.5	12.0	142	5.0	85	385	30	64.2	4660	3470	6.1
...	6.0	142	1.25	87	80	3.0	12.0	142	5.0	85	335	20	62.4	3160	3650	6.3
3.5[b]	3.5	170	0.5	80	70	3.5	3.5	170	0.5	80	315	30	62.8	4700	6700	6.7
Commercial boards: Standard, 2 brands													58–61	4040–6600	3520–4100	3.1–3.4
High-density, 2 brands													63–65	5070–8000	4760–5400	4.4–4.5

[a] Developed by beater refining.
[b] Neutral sulfite-type cooks: Chemical is sodium sulfite and sodium bicarbonate.

Table III. Variation in Yield of Refined Pulp with Time and Chemical Concentration[a]

Lime, %	Digestion time, hr. 1.0	3.5	6.0
6	94.0	88.0	82.8[b]
	90.0	86.3	86.0[b]
9	88.8	90.0	87.8
	90.4	87.6	84.0
12	92.0	87.0	87.6
	89.4	86.8	86.2

[a] Results of duplicates shown.
[b] pH after cooking, 8.6 to 8.8. For all other runs pH was 11.4 to 11.9.

a disk mill fitted with either devil-tooth or grid-type plates. In some instances both rapid- and slow-draining pulps were prepared from a single digestion by refining a portion of the fast pulp to a freeness of about 350 ml. (Schopper Riegler) in a beater or in a vertical refiner. The rapid- and slow-draining pulps were blended in various combinations, and the blends used to form 11-in. diameter mats as described previously by Lathrop and Naffziger (*12*). Wet mats were cold-pressed between 16-mesh screen at 20 p.s.i. for 1 min. to remove excessive water and to compact the fibers. Mats for insulating boards were then placed in a forced-draft oven at 150°C. for 7 hr. In the absence of controlled humidity in the oven the mats were turned frequently to facilitate uniform drying from all surfaces and to minimize any tendency to warp. Mats for hardboards were press-dried between a polished stainless-steel platen (top) and a 16-mesh screen (bottom) at 188°C. and a pressure of 1225 p.s.i. for 14 min. Dried specimens for insulating boards and hardboards were conditioned at 23°C. and 50% R.H. for at least 16 hr. before testing for density, modulus of rupture, tensile strength, and resistance to impact. Data covering the preparation of some selected fast- and slow-draining bamboo pulps, their use in board compositions, and some physical properties for $^1/_2$-in. experimental insulating boards, as well as the commercial controls, are presented in Table I. Similar information for hardboards is presented in Table II.

Boardmaking with Lime

In continuing the investigation of phase I, lime was selected as the pulping chemical for the pilot-plant evaluation of timer bamboo as the raw material from which to produce structural boards. The experimental design consisted of a 3 by 3 factorial in randomized blocks with two replications. The independent variables were strength of chemical (6, 9, and 12% lime, basis dry chips) and cooking time (1, 3.5, and 6 hr.). The data were evaluated by analysis of variance to assess the influence of the independent variables on the quality of the pulps as measured by strength characterestics of insulating and hardboards. The analysis included tests for mean differences that were greater than could be accounted for merely on the basis of random variability.

Cooking was performed in a jacketed, 3-ft. globe digester rotating at 1 r.p.m. Pulps were prepared as follows:

Thirty-two pounds (dry basis) of bamboo chips were placed in the digester and the requisite amount of slaked lime added with water to make a 6:1 liquid-solids ratio. The digester contents were heated by indirect steam. The cooking period did not include the 45 min. required to heat the digester to operating temperature or the 30 min. required for blowdown. At the completion of a cook the contents were transferred onto a screen where chips were washed repeatedly to remove unused lime. The chips at about 15% consistency were passed through a 24-in. double-disk refiner fitted with devil-tooth plates set at 0.025-in. clearance. The pulp from the refiner was rapid-draining. Variations in yield of this pulp, with respect to digestion time and strength of lime, are shown in Table III. Approximately 5-lb. (dry basis) portions from each batch of rapid-draining pulp were hydrated in a beater to a Schopper Riegler freeness of about 350 ml. The two types of pulp were then ready for use in forming insulating and hardboards according to TAPPI Suggested Method T 1001 sm-51.

Insulating boards were prepared as 14 by 14-in. specimens from 70:30 blends of fast- and slow-draining pulps from each of the 18 cooks in four density ranges; namely, 15.5 to 16.5; 16.5 to 17.5; 17.5 to 18.5; and 18.5 to 19.5 lb. per cu. ft. Three specimens were prepared for each condition. Weighed quantities of each pulp (rapid- and slow-draining) sufficient to form a single specimen of a specific density were blended and placed in a board-forming mold; the consistency was adjusted to 1% before forming the mats. Wet mats were cold-pressed to 0.5-in. stops for 30 sec. then dried in a forced-draft oven as described in phase I. Conditioning prior to testing remained the same as described.

Tensile strength parallel to board surface was evaluated according to ASTM Standard C209-57T for testing structural insulating board made from vegetable fibers. Flexural characteristics of the boards were determined according to TAPPI Suggested Method T 1003 sm-55, except that the span between specimen supports was reduced from 12 to 8 in. because of the flexibility of the bamboo boards. Resistance to impact in the direction of pressing the mats was determined on unnotched 0.5 by 0.5 by 2.5-in. specimens with an Izod-type impact tester (ASTM Standard D256-56). Values for strength properties of specimens representing the 70:30 blends of rapid- and slow-draining pulps from the three cooking periods (1, 3.5, and 6 hr.) are presented in Table IV.

Hardboards were also prepared as 14 by 14-in. specimens, but in $^1/_8$-in. thickness. The mats were formed by the same procedures as used for insulating boards, except that the ratio of rapid- to slow-draining pulp was 80:20 and weights were adjusted to give final densities in four ranges; namely, 49 to 52, 52 to 55, 55 to 58, and 58 to 61 lb. per cu. ft. These densities were achieved by pressing mats containing appropriate amounts of pulp at pressures of 500, 675, 850, and 1225 p.s.i. for periods of 16 min. at 188°C. Of the 12 boards representing a single cooking condition, three specimens were pressed at each of the indicated pressures. All hardboard specimens were conditioned and tested for the same characteristics as for the insulating boards. (Table V)

The commerical insulating and hardboards were characterized by the same procedures employed for evaluating the experimental boards.

DISCUSSION

Investigations with Various Chemicals

Results for small-scale pulping and preparation of

Table IV. Variations in Strength Properties of Insulating Boards from Lime-Cooked Bamboo Pulps (70 Parts Rapid-Draining: 30 Parts Slow-Draining) with Board Density and Cooking Time[a]

Length of digestion, hr.	Density, 15.5–16.5 lb./cu. ft. — Flexural: Modulus of rupture, p.s.i.	Flexural: Max. deflection, in.	Tensile, p.s.i.	Impact strength, ft. lb./sq. in.	Density, 16.5–17.5 lb./cu. ft. — Flexural: Modulus of rupture, p.s.i.	Flexural: Max. deflection, in.	Tensile, p.s.i.	Impact strength, ft. lb./sq. in.	Density, 17.5–18.5 lb./cu. ft. — Flexural: Modulus of rupture, p.s.i.	Flexural: Max. deflection, in.	Tensile, p.s.i.	Impact strength, ft. lb./sq. in.	Density, 18.5–19.5 lb./cu. ft. — Flexural: Modulus of rupture, p.s.i.	Flexural: Max. deflection, in.	Tensile, p.s.i.	Impact strength, ft. lb./sq. in.
1.0[a]	270	0.45	210	1.05	300	0.55	230	1.20	340	0.55	260	1.30	380	0.55	290	1.45
3.5[a]	280	0.45	210	1.20	330	0.45	250	1.35	360	0.50	300	1.50	410	0.50	340	1.65
6.0[a]	280	0.50	210	1.20	330	0.55	260	1.35	370	0.55	300	1.50	430	0.55	340	1.70
Commercial insulating boards: 6 samples													250–400	0.20–0.30	170–280	0.6–1.50

[a] Data for digestions with 6, 9, and 12% lime have been combined; values represent averages of specimens resulting from six digestions, two digestions at each level of lime used.

insulating boards (Table I) indicated that of the chemicals tried lime alone was the most practical from the standpoint of pulp yields and strength of specimen. Board specimens prepared from slow-draining pulps from cooks using combinations of lime and caustic soda had higher strength, but their densities were increased to impractical levels. Values for strength characteristics increased as the content of slow-draining pulp in the blends was increased from 0 to 30%. The best experimental board with a density comparable to that of commercial insulating boards was prepared from the blend resulting from cooking bamboo chips with 12% lime at 142°C. for 1 hr. The 88% yield was near maximum for this phase of the study. These results indicate that lime alone suffices as the pulping agent for the preparation of both rapid- and slow-draining bamboo pulps to be used in the production of insulating boards.

Data (Table II) acquired in phase II also indicate that hardboards having strength properties equal to or surpassing those of standard commerical hardboards can be produced from bamboo pulps prepared under a variety of conditions. Yields of pulp are favored by the use of lime, and although there was some sacrifice in strength properties, the values were still competitive with those of commercial boards. Use of lime alone appears justified on the basis of both strength and economy.

Boardmaking with Lime

Results of the phase II investigation substantiate the results and observations of phase I. In these pilot-plant investigations a pronounced excess of lime was observed in the chips at the end of the cooking periods with the exception of the two cooks made with 6% lime for a period of 6 hr. Yields from individual cooks ranged from 83 to 94%. As might be expected, the higher yields were obtained with the shorter cooking periods. No significant differences in yields appeared attributable to changes in amount of lime charged into a digestion with the exception of the 6%, 6 hr. combination where the yield was significantly lower. Since excess chemical was usually present, the experimental variation turned out to be primarily that of the time factor. Consequently, Tables IV and V were so set up that average properties of boards from all cooks at the specified time intervals—regardless of amount of chemical added—are presented. The individual experiments (not shown) provide values of board properties that justify this procedure of neglecting effects of chemical concentration.

For insulating boards (Table IV) the values for modulus of rupture, tensile strength, and resistance to impact increased as the board density increased. Values for these characteristics also improved in the upper density ranges as the time of cooking bamboo chips increased. Boards in all density ranges had strength characteristics comparable to those of commercial boards in the 18.5 to 19.5 lb. per cu. ft. range. Resiliency of experimental boards, as judged by midspan deflection values, was significantly greater in all instances than for the commercial materials examined. These values did not change appreciably with density, but were slightly greater at other than the lowest density range. No significant benefits appear to accrue from cooking the bamboo chips beyond 3.5 hr.

Results obtained for hardboards (Table V) generally parallel those for the insulating boards with regard to characteristics and trends. Again, no advantages were gained from cooking beyond the 3.5-hr. period. Values for modulus of rupture, tensile strength, and resistance to impact increased with an increase in density within the respective time periods. As for insulating boards, the values for the midspan deflection were greatest at the highest density, but the changes were not related directly to the increases in density. Strength characteristics of the experimental bamboo hardboard were comparable to those of standard commercial hardboard;

Table V. Variations in Strength Properties of Hard board from Lime-Cooked Bamboo Pulps (80 Parts Rapid-Draining: 20 Parts Slow-Draining) with Board Density and Cooking Time[a]

Length of digestion, hr.	Density, 49–52 lb./cu. ft. — Flexural: Modulus of rupture, p.s.i.	Flexural: Max. deflection, in.	Tensile, p.s.i.	Impact strength, ft. lb./sq. in.	Density, 52–55 lb./cu. ft. — Flexural: Modulus of rupture, p.s.i.	Flexural: Max. deflection, in.	Tensile, p.s.i.	Impact strength, ft. lb./sq. in.	Density, 55–58 lb./cu. ft. — Flexural: Modulus of rupture, p.s.i.	Flexural: Max. deflection, in.	Tensile, p.s.i.	Impact strength, ft. lb./sq. in.	Density, 58–61 lb./cu. ft. — Flexural: Modulus of rupture, p.s.i.	Flexural: Max. deflection, in.	Tensile, p.s.i.	Impact strength, ft. lb./sq.in.
1.0[a]	3450	1.10	2500	3.5	3730	1.20	2980	3.8	3860	1.25	3320	4.2	4440	1.30	3470	4.5
3.5[a]	3770	1.25	3060	4.1	4240	1.30	3330	4.5	4690	1.30	3680	4.8	5060	1.30	3980	5.2
6.0[a]	3880	1.15	2640	4.2	4280	1.20	3040	4.6	4540	1.20	3600	4.9	4930	1.20	4110	5.2
Commercial boards: Standard, 2 samples													4040–6600	0.75–....	3520–4100	3.1–3.4
High-density,[b] 2 samples													5070–8000	0.90–1.30	4760–5400	4.4–4.5

[a] Data for digestions with 6, 9, and 12% lime have been combined; values represent averages of specimens resulting from six digestions, two digestions at each level of lime used.
[b] Density, 62.7–64.9 lb./cu. ft.

their resiliency and resistance to impact were equivalent to those of high-density commerical boards.

Because of the techniques employed the experimental boards had surface textures similar to those of commonly available boards. Bamboo fiber boards should lend themselves directly to the usual applications for commercial fibrous insulating and hardboards.

Analysis of variance for yield of pulp and for strength characteristics substantiates interpretations based on general observation of the data. Differences among the means of the time treatment were significant for yields. Also, significant differences among the means for time were noted for resistance to impact for hardboard at the four density levels when the same amount of lime was used.

In conclusion, when *Phyllostachys bambusoides* is pulped with 6 to 12% lime at 142°C. for periods of 1 to 3.5 hr., it can be used to prepare insulating and hardboards having strength properties comparable to those of commercial boards made from pulpwood.

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Structural Weaknesses in Softwood Pulp Tracheids

O. L. FORGACS

Softwood pulp tracheids are shown to be structurally weak at the sites which were in contact with ray cells in the wood. Disintegration of the cooked chips causes the tracheids to flex at these points, with resultant points of damage to the cell wall, which have been termed "nodes." The tracheids tend to swell, bend and rupture preferentially at the nodes, and evidence is presented that rupture at the nodes plays a significant part in fiber shortening during the beating process.

In the course of recent studies, conducted in these laboratories, of the flexibility of papermaking pulp fibers (*1*, *2*), it was observed that the tracheids of undried softwood pulps, frequently bent in segments rather than continuously along their lengths, as illustrated in Fig. 1. The lower the yield to which the wood had been cooked, the greater was the proportion of tracheids which bent in this manner. In low-yield pulps, segmental bending was much more frequent than smooth continuous bending, irrespective of whether the pulps had been made by the sulfite or the kraft process.

It was also noted that the weak points along a tracheid at which the greatest amount of bending occurred were often spaced at strikingly regular intervals of between 0.2 and 0.4 mm. These points showed up vividly between crossed polaroid filters indicating that the cell wall had been deformed there, or at least that the fibrillar orientation of the cell wall had been distorted. The point at which this deformation occurs has been termed a "node" (*1*). Since this term suggests to the botanist periodic thickenings of a plant stem or branch, and to the physicist specific features at repeated intervals, it also seemed appropriate for describing these cell-wall deformations.

Such evidently weak points in the cell wall of pulp tracheids must influence the physical and mechanical properties of the tracheids, and hence their papermaking characteristics. An investigation of their nature and causes was therefore undertaken.

Several studies of transverse deformations in the cell wall of hardwood fibers and softwood tracheids have been reported in the literature. Mostly these have dealt with so-called "slip-planes" and "minute compression failures." A comprehensive literature review of this subject was published by Wardrop and Dadswell (*3*).

The slip-planes and minute compression failures appear under the microscope as lines across the cell wall and usually occur at an angle of between 20 and 80° to the fiber axis. They show up brightly when the fibers are viewed between crossed polaroid filters so that the axis of the fiber is aligned in the extinction position. This indicates that the spiral fibrillar arrangement of the cell wall has folded or been distorted (*4*). A typical example of slip-planes and minute compression failures in a spruce sulfite pulp tracheid is shown in ordinary and in polarized light in Figs. 2 and 3.

Such deformation can arise in the tree, probably as

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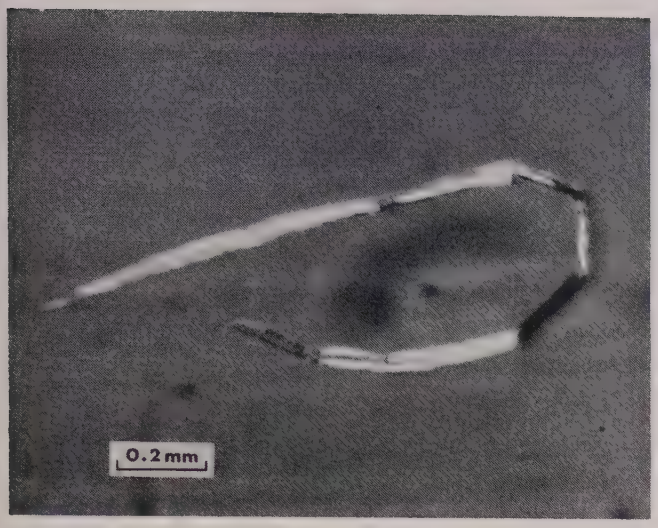

Fig. 1. Photomicrograph between crossed polaroid filters of a spruce sulfite tracheid undergoing segmental bending

The bending stresses were applied by suspending the tracheids in a viscous liquid and then shearing the suspension in a Couette apparatus (*1*). In the tracheid shown, the greatest bending occurred at eight discrete points.

the result of growth stresses and movement of the tree in the wind. They can also be produced by artificial compression of the wood. In each case, the deformation of the cell wall occurs along clearly defined lines. No relationship between the location of pits and the location of slip-planes and minute compression failures appears to have been established.

Deformations of the cell wall of sulfite pulp tracheids "at surprisingly regular intervals" have been reported and illustrated by Emerton (*5*). These features were called "nodal gatherings," because it was originally thought that the deformations might be gatherings of the S_1 layer, resulting from incipient swelling of the tracheids during the pulping process. However, it was subsequently shown that the association of S_1 gatherings with these periodic features had resulted from a misinterpretation of the micrographs (*6*). Both the spacing and the appearance of the deformations pointed out by Emerton suggested that the weak points observed in the flexibility studies (*1*, *2*) were identical features.

In this paper, the results of a microscopic examination of nodes in softwood pulp tracheids are described. It is shown that the nodes represent incipient rupture of the cell wall, and that their positions in the cell wall frequently coincide with the sites on the tracheids which were in contact with radial ray cells in the wood. Evidence is presented that the nodes appear as the result of the combined action of pulping and mechanical disintegration of the cooked chips, and that further mechanical treatment, such as beating, often leads to complete rupture of the tracheids at the nodes.

DESCRIPTION OF NODES

Microscopic examination of the tracheids of unbeaten black spruce sulfite and kraft pulps revealed that nearly all the tracheids had nodes. Some of the longer tracheids had as many as 12 to 14 spaced along their lengths. In tracheids which had never been dried, the nodes appeared either as bulges or constrictions of the cell wall, as shown in the photomicrographs Figs. 4, 5, 6 and 7. These show that the cell wall has suffered

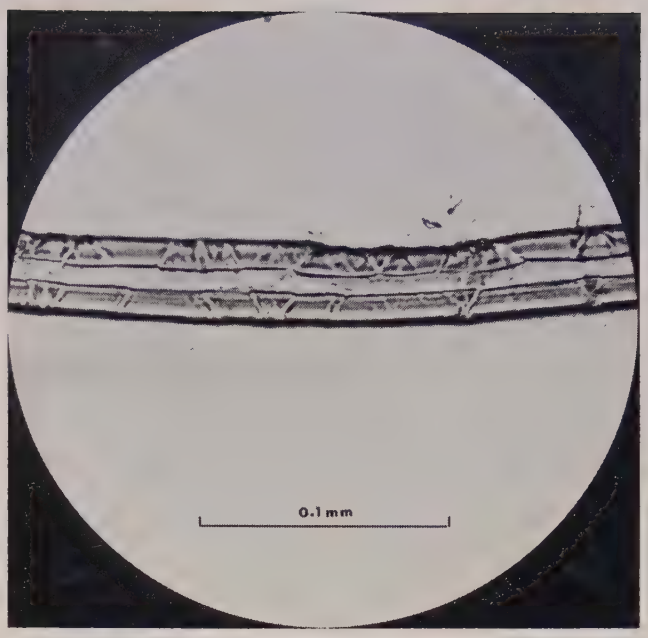

Fig. 2. Slip-planes and minute compression failures in an undried, spruce sulfite pulp tracheid (latewood), in ordinary light, green filter

considerable distortion and wrinkling at these points. Figure 5, which is a photomicrograph of the same field as Fig. 4 using crossed polaroid filters, shows the extent of the damage in terms of the birefringence at the nodes when the axis of the tracheid was in the extinction position. While some minute compression failures are frequently evident at the nodes, the damage is obviously far more extensive than can be attributed merely to minute compression failures (cf. Figs. 2 and 3). The intensity of the birefringence also shows that disruption has occurred across the S_2 layer of the cell wall, in which the bulk of the cellulosic material is located, and in which the microfibrils are most highly orientated.

In the lower tracheid in Fig. 6, and in the tracheid in Fig. 7 the nodes have occurred in the region of cross-field pitting, that is, at the site which was in contact

Fig. 3. Photomicrograph of the tracheid shown in Fig. 2, between crossed polaroid filters

Fig. 4. Photomicrograph of an undried, spruce sulfite pulp tracheid (latewood), showing two nodes

These wrinkled deformations of the cell wall correspond to the points of greatest bending as shown in Fig. 1.

with ray cells in the wood and throughout this investigation, evidence accumulated that the coincidence of nodes with ray crossings was typical.

In tracheids which had been air-dried on a microscope slide, the nodes usually appeared as constrictions, as shown in Fig. 8, which also illustrates well the periodic occurrence of the nodes along the lengths of the two tracheids which cross the microscope field diagonally. Figure 9 is a micrograph of a node in a tracheid which was dried on a metal stub and photographed in a scanning reflection electron microscope (*7*). Again, the node occurred in the region of cross-field pitting, as indicated by the small bordered pits

Fig. 5. Photomicrograph of the tracheid shown in Fig. 4, between crossed polaroid filters

The intensity with which the nodes show up indicates that deformation at the nodes has occurred across the S_2 layer, which contains the bulk of the cellulosic material of the cell wall.

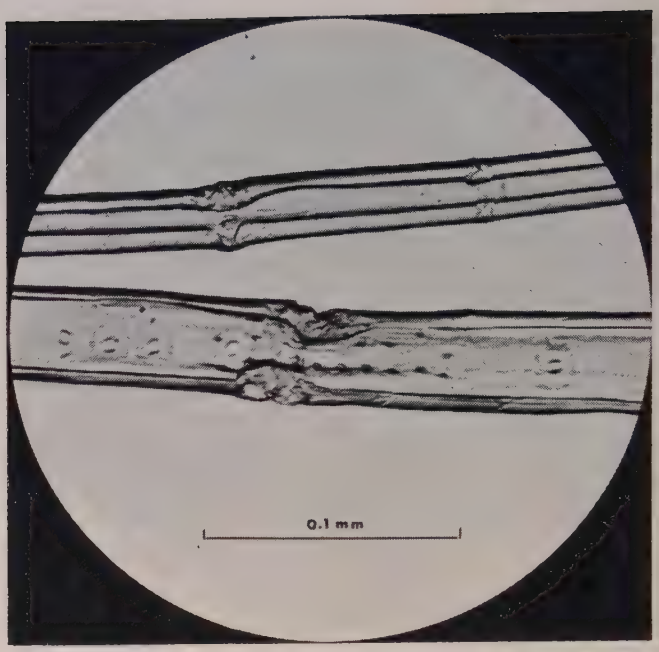

Fig. 6. Typical node (lower tracheid) in an undried, spruce sulfite tracheid (earlywood)

The deformation of the cell wall occurred at the site which was in contact with ray cells in the wood, as shown by the simple pits.

and the simple pits. Examination of a large number of tracheids in the scanning electron microscope at higher magnifications indicated that the S_1 layer had folded at the nodes but there was no evidence of rupture of S_1 at the nodes, or elsewhere along the tracheids. This again suggests that the damage is essentially in the S_2 layer. The constriction of the cell wall at the nodes in dried tracheids may therefore be interpreted as collapse of the weakened S_2 layer into the lumen during shrinkage.

Several tracheids which were observed to have nodes in the undried state were removed from suspension by means of fine tweezers, and allowed to dry without the constraining effect of surface tension which normally acts between the tracheids and a solid surface such as

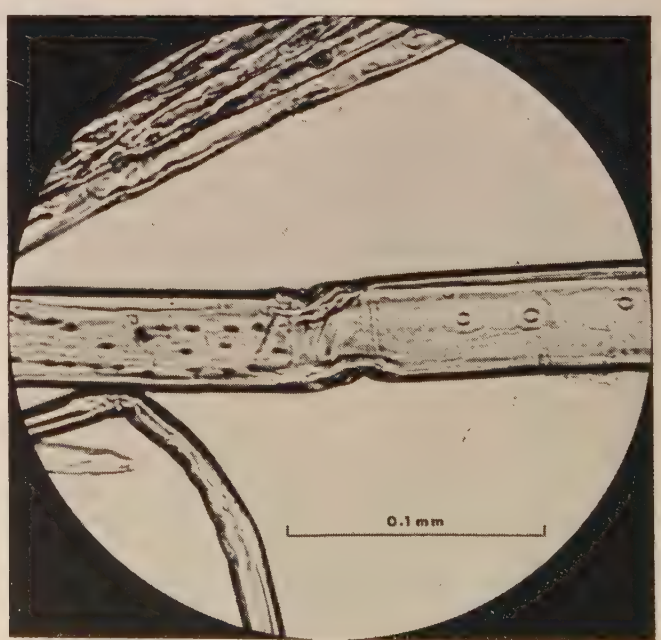

Fig. 7. A node in a spruce kraft pulp (earlywood) tracheid

The node has occurred at the edge of the ray crossing.

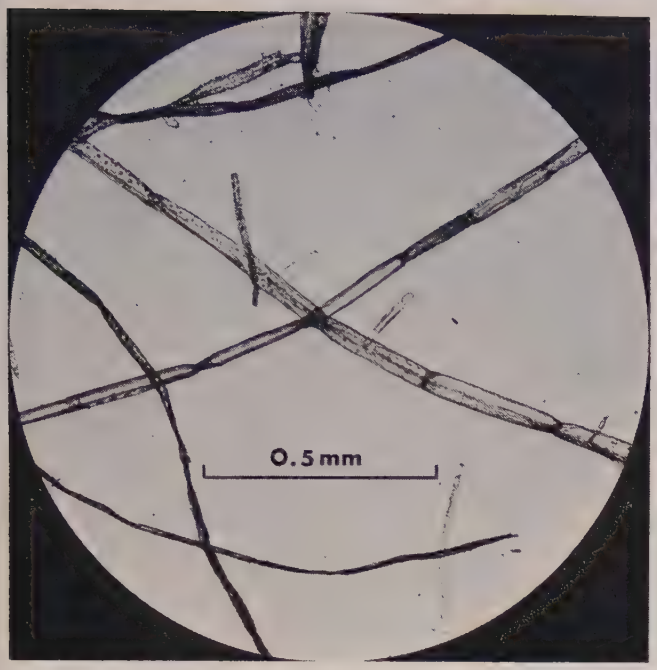

Fig. 8. Low yield, spruce sulfite pulp tracheids which have been dried-down on a microscope slide

Several nodes are visible as constrictions in the cell wall in both tracheids which cross the field. The typical spacing between the nodes is illustrated.

a microscope slide or stub. By observing the tracheids through a stereomicroscope, it was found that the twisting which results from shrinkage of the helical cell structure and the collapse of the lumen during drying almost totally obscured the nodes which had been clearly visible in the undried state. It was also found that tracheids which had been dried by suspension in a nonaqueous liquid (e.g., silicone oil) no longer exhibited segmental bending when the suspension was sheared in the Couette apparatus (*8*).

Fig. 9. Scanning electronmicrograph of a node in a dried spruce sulfite tracheid

The cell wall has collapsed into the lumen. Note the small bordered pits (top left) which connected the tracheid to ray tracheids in the wood, and the simple pits which connected the tracheid to ray parenchyma cells. The minute wrinkles are the result of shrinkage of the underlying S_2 layer during drying.

Nodes were found to occur with approximately equal frequency in both early- and latewood tracheids, though they were generally more pronounced in the latewood tracheids, an effect which may be attributed to the thicker cell walls in latewood. However, nodes occurred very rarely in tracheids which had the characteristic striations of compression wood, and they never occurred at periodic intervals; it is of interest to note that minute compression failures, too, are not generally found in compression wood (*3*).

The foregoing observations were made on one spruce sulfite and one kraft pulp. The occurrence of nodes in tracheids prepared under different pulping conditions, and in tracheids of different Canadian softwood species commonly used in commercial papermaking practice is treated in the next section.

THE OCCURRENCE OF NODES

The Effect of the Method of Pulping

The relationship between pulp yield and the occurrence of nodes in the tracheids of undried pulps was investigated quantitatively.

The experiments were conducted on five sulfite and five kraft pulps covering a range of yields between 70 and 45%, and one experimental bisulfite pulp. The pulps had been prepared from black spruce in the pilot plant of the Pulp and Paper Research Institute. These pulps had been given the minimum amount of mechanical treatment to effectively disintegrate the cooked chips.

Samples of undried tracheids were mounted on slides and projected on a screen by means of a projection microscope and the percentage of tracheids which had two or more nodes was estimated for each pulp. All whole tracheids on each slide were included in the sampling. At least 100 tracheids were examined for each pulp sample.

The results, Table I and Fig. 10, showed that there was a close correlation between the number of tracheids with nodes and the pulp yield. No tracheids with nodes were apparent above 70% yield, but at lower yields the number of tracheids with nodes increased with decreasing yield. This result was in qualitative agreement with the observations of the occurrence of segmental bending of tracheids during flexibility measurements in the Couette apparatus.

Figure 10 also shows that the correlation between yield and per cent tracheids with nodes did not vary appreciably with the method of pulping in the samples tested. It should, however, be pointed out that the kraft pulps required more mechanical treatment to disintegrate them than the sulfite pulps of corresponding yields.

Occurrence of Nodes in Different Wood Species

Pilot-scale pulps of five species of Canadian softwoods other than black spruce (*Picea mariana*) were examined for nodes. It was found that nodes were present in the tracheids of balsam fir (*Abies balsamea*), Douglas-fir (*Pseudotsuga taxifolia*), jack pine (*Pinus banksiana*), and western hemlock (*Tsuga heterophylla*).

The percentage of tracheids having two or more

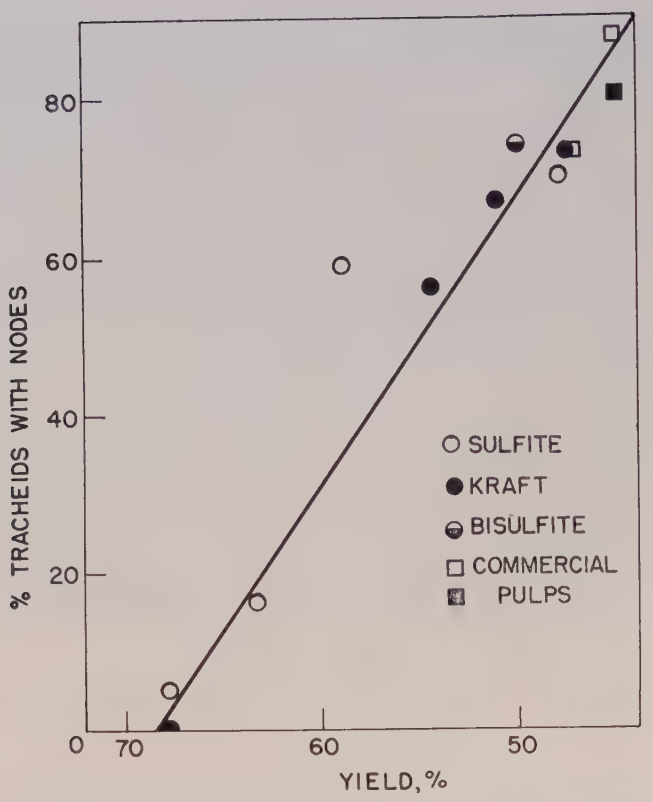

Fig. 10. The percentage of tracheids having two or more nodes as a function of pulp yield

The number of tracheids with nodes increases with decreasing yield.

nodes was estimated as before in the jack pine, western hemlock, and Douglas-fir pulps: the results are given in Table II. Comparison with Table I shows that the number of tracheids with nodes was of the same order of magnitude in all these species.

Two hardwood pulps, namely birch (*Betula papyrifera*) kraft and oak (*Quercus rubra*) kraft, were also examined. Although many of the fibers had minute compression failures, no features which could be classed as nodes either in appearance of periodicity were identified.

Occurrence in Commercial Chemical Pulps

Finally, the occurrence of nodes in three commercial chemical pulps was estimated. Table III shows that the occurrence of nodes appears to correspond closely with the results for the pilot-scale softwood pulps.

The above-mentioned quantitative estimates of the occurrence of nodes were probably low. The large microscope field necessary to make measurements on a large number of fibers could only be obtained at the expense of resolution. Thus comparatively small deformations of the cell walls, which might have been identified as nodes under more favorable microscopic conditions, were probably neglected. Observations of the pulps in the Couette apparatus showed that in low yield black spruce pulps, at least 90% of the tracheids over 1 mm. in length underwent segmental bending, which again suggested that the estimates presented above were low. However, the results do demonstrate the progressive development of nodes with pulping, and show that they are present to an approximately equal extent in the tracheids of the softwood pulps examined.

Table I. Pilot-Scale Pulps

Species	*Yield,* [a] *%*	*Tracheids with 2 or more nodes, %*
Black spruce sulfite	73.8	0
	67.8	5
	63.3	16
	58.9	59
	47.9	70
Black spruce kraft	76.7	0
	67.8	0
	54.4	56
	51.0	67
	47.3	73
Black spruce bisulfite	50.0	74

[a] Yield = moisture-free pulp/wood.

Table II. Pilot-Scale Pulps

Species	*Process*	*Yield,* [a] *%*	*Tracheids 2 or more nodes, %*
Jack pine	Kraft	52.7	48
	Sulfite	56.0	56
West hemlock	Kraft	55.0	60
Douglas-fir	Kraft	47.0	80

[a] Yield = moisture-free pulp/wood.

THE FORMATION OF NODES

A simple experiment was conducted to determine whether the nodes were formed during the pulping process, or as the result of subsequent disintegration of the cooked chips.

Three or four chips of the 48% yield black spruce sulfite pulp were gently disintegrated in a 1000-ml. beaker by means of a blunt laboratory stirrer. After partial disintegration had occurred some of the suspension was removed and examined under the microscope. It was found that only 20% of the tracheids which had been isolated had two or more nodes, as compared with 70% in the pulp disintegration by the normal means.

The dependence of the number of tracheids with nodes upon the method of disintegration indicated that the nodes were not present in the pulped chips, but resulted from the mechanical treatment.

Fragments composed of partially separated tracheids were also examined. It was found that the fragments tended to split off the chips in radial lamellae one tracheid thick. Many of these layers were observed to have highly birefringent lines of damage which invariably ran along the site previously occupied by the ray cells as illustrated in the photomicrograph Fig. 11. The site of the ray cells is indicated by the characteristic simple pits. The line of damage shown in Fig. 11 appears as nodes in the isolated tracheids, Fig. 12.

Two further tests were conducted to check the apparent coincidence of the nodes with the ray crossings.

1. Over 100 nodes in about 25 spruce sulfite tracheids were carefully examined in ordinary and in polarized light. It was found that over 80% of the nodes were definitely associated with ray crossings. About 5% were definitely not associated with ray crossings,

Table III. Commercial Pulps (Unbeaten)

Species	*Process*	*Approx. yield,* [a] *%*	*Tracheids with 2 or more nodes, %*
Spruce-balsam	Sulfite	45	88
Spruce-balsam	Sulfite	48	70
Douglas-fir–west hemlock	Kraft, semi-bleached	45	80

[a] Yield = moisture-free pulp/moisture-free wood.

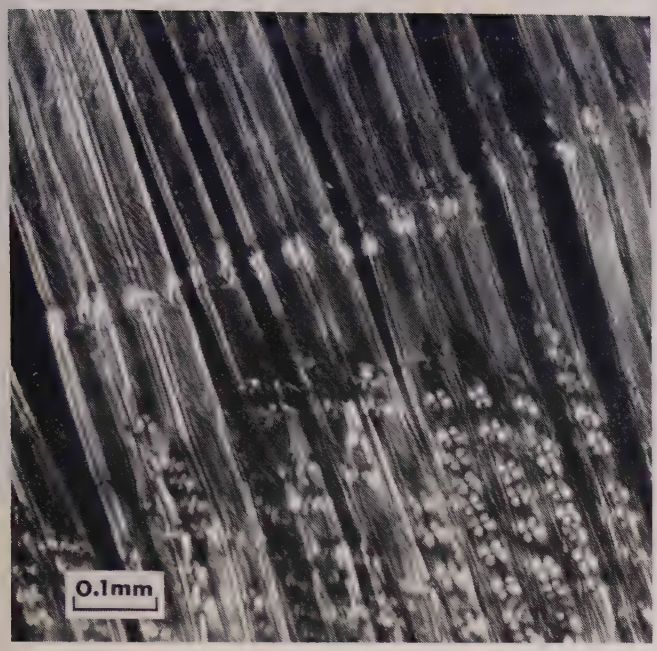

Fig. 11. A sliver of partially dispersed sulfite pulp tracheid photographed between crossed polaroid filters

The bright line running across the tracheids in the region which was in contact with radial ray cells in the wood indicates damage to the cell walls.

while no certain conclusions could be drawn for the balance. It was also noted that when the ray crossing was short (i.e., 5 or less ray cells in height) then the nodes usually occurred across the ray crossing as shown in Fig. 6. When the ray crossing was long (i.e., more than 5 ray cells) the nodes tended to occur at one and occasionally at both ends of the ray crossing, e.g., Fig. 7.

Microscopic examination of tangential sections of black spruce showed that only 40 to 50% of the radial sides of the tracheids were in contact with ray cells in the wood. The figure of 85% for the coincidence of ray crossings with nodes was therefore highly significant.

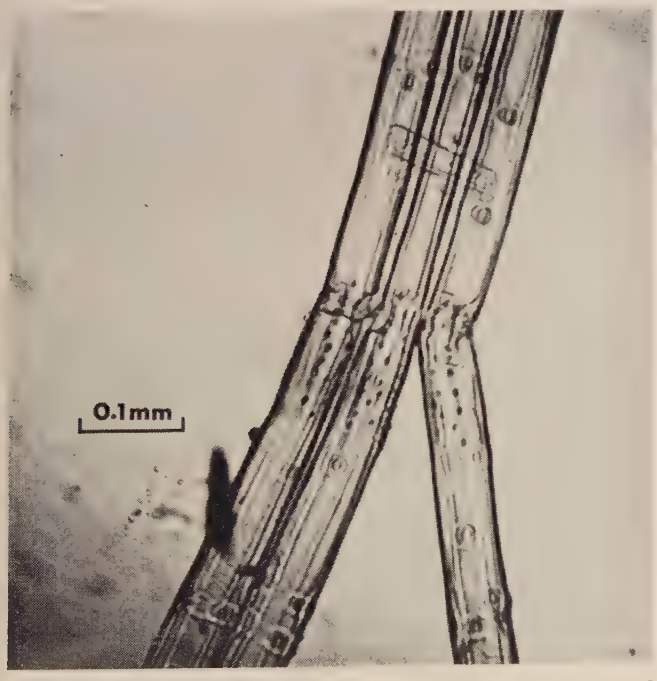

Fig. 12. Three partially dispersed tracheids. Typical nodes have occurred in the region of the ray crossing

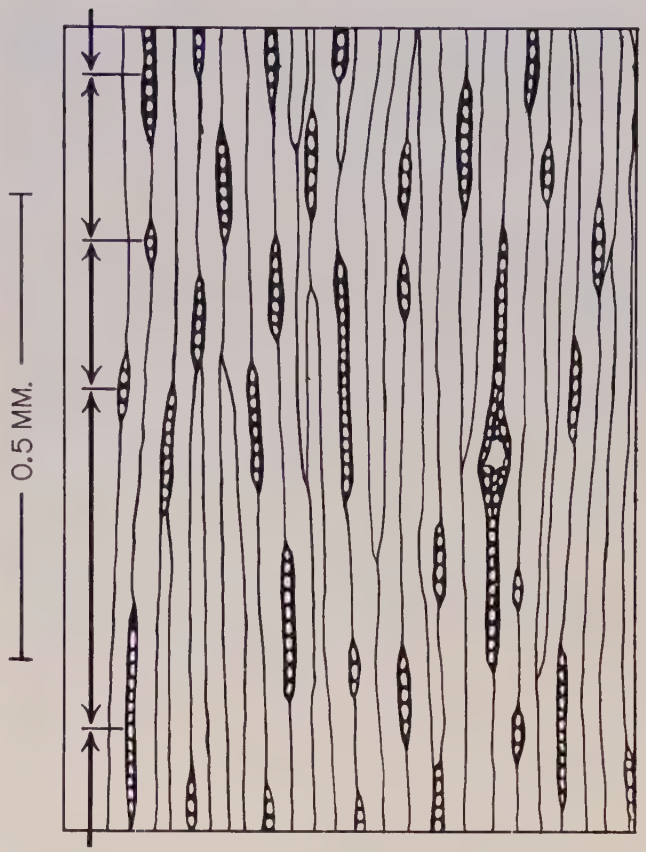

Fig. 13. Tracing of a micrograph of a tangential section of spruce wood

The arrows show how the spacings between the centers of adjacent ray crossings were measured.

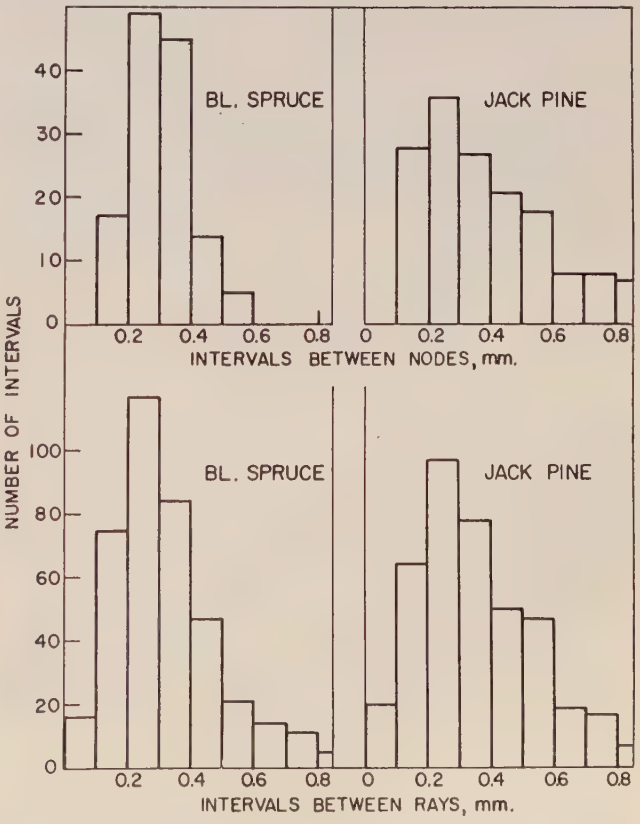

Fig. 14. The distribution of intervals between adjacent nodes in tracheids of 48% yield spruce and 48% yield jack pine sulfite pulps, compared with the distribution of intervals between ray crossings in the corresponding woods

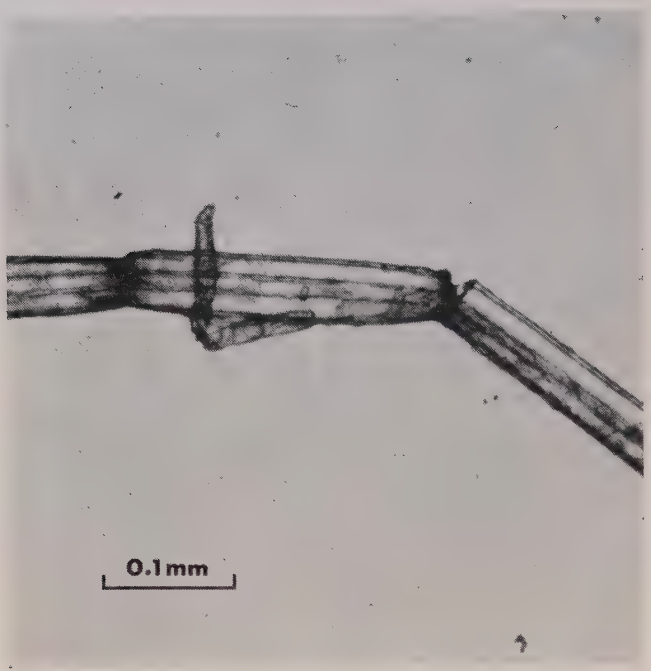

Fig. 15. Low yield, spruce sulfite pulp tracheid (air-dried on a slide) showing incipient rupture at a node

2. Further evidence for the coincidence of nodes with ray crossings was obtained by measuring the vertical distances between the centers of adjacent ray crossings along the lengths of tracheids in tangential sections of black spruce and jack pine as illustrated in the tracing Fig. 13, and by comparing the distributions of these spacings with the distances between adjacent nodes in low-yield pulp tracheids of the corresponding woods.

The remarkable correlations between these distributions is shown in Fig. 14. This again points to the frequent coincidence of ray crossings with the nodes.

It may be concluded that the sites of ray crossings are weak points in the tracheids. Garland (*9*) noted that the curves of softwood tracheid walls at the edges of rays often proved to be the points where wood tended to fracture in tension and compression. Since the nodes are also frequently found at the edges of the rays, it appears that these points are also structurally weak in pulp tracheids, and that the weakness is manifested as nodes when the cooked chips are subjected to flexing during mild mechanical treatment.

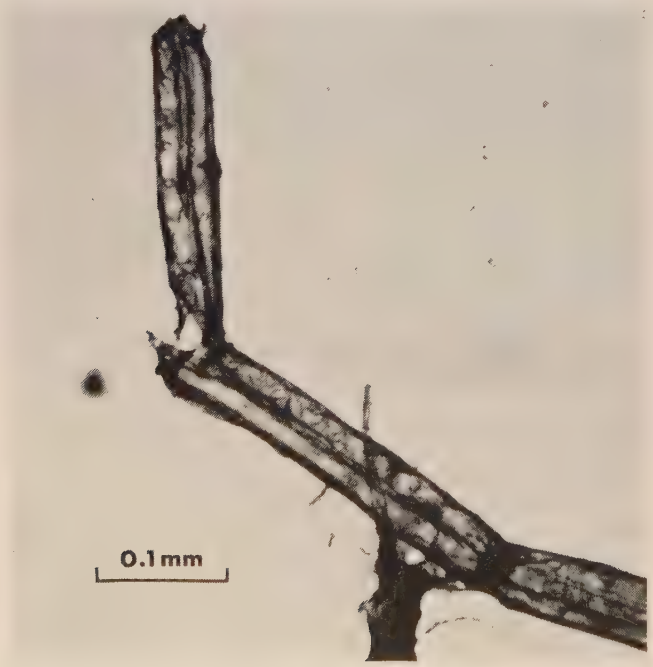

Fig. 16. Low yield, spruce sulfite tracheid (air-dried on slide)

Complete rupture has occurred at a node at the top end of the tracheid. Partial rupture has occurred at the intermediate node. The tracheid is still intact at the node at the bottom right of the field. Rupture at the nodes contributes to tracheid shortening during the beating process.

FURTHER EVIDENCE FOR THE STRUCTURAL WEAKNESS OF NODES

It has already been mentioned that the nodes are points of preferential bending. It was of interest to examine also the effect of tension and swelling on fibers which had nodes.

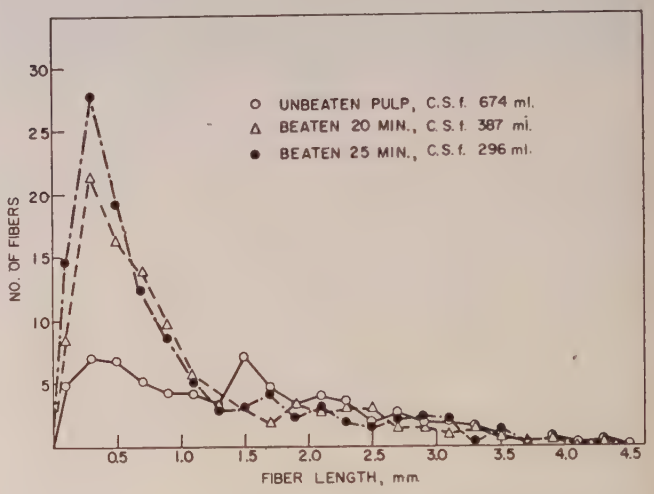

Fig. 17. Fiber length distributions, normalized to a constant total length, of an unbeaten spruce sulfite pulp and at two different degrees of beating

The rapid growth of the peak between 0.2 and 0.4 mm. suggests that rupture of the tracheid at the nodes plays a significant part in tracheid shortening.

Tension

A dilute water suspension of tracheids was placed on a microscope slide and individual tracheids were pulled in opposite directions along their axes by means of two jeweler's tweezers without removing them from the suspension. The effect was observed by means of a stereomicroscope using reflected light at a magnification of 20×.

It was found that the tracheids usually ruptured in the jaws of the tweezers. With perseverance, however, many ruptures of the portion of the tracheids between the tweezers were produced, and in each case, rupture occurred at a node. This shows that the nodes represent weak points under tensile as well as bending stresses.

Swelling

A sample of spruce tracheids suspended in a drop of water was placed on a slide. A solution of cuprietylenediamine was introduced under the cover glass. The swelling behavior of tracheids with nodes was observed microscopically.

The first change observed during swelling was that

the tracheid straightened and the nodes disappeared. At the same time, the diameter of the cross section increased, until "balloons" suddenly erupted at the points along the cell where the nodes had formerly been located. Subsequently, ballooning occurred also at intermediate points along the axis of the cell.

This corroborates Steenberg's observation that pulp tracheids have a tendency to swell first at points at which they had previously been flexed (*10*).

THE FUNCTION OF NODES IN BEATING

It has been shown that nodes in softwood pulp tracheids represent points at which the tracheids will bend, rupture under tension, and swell preferentially. Therefore one might expect that mechanical failure at the nodes would be a contributing factor to fiber shortening during the beating process.

A 48%-yield spruce sulfite pulp was beaten in a $1^1/_2$ lb. Valley beater which had blunt bars. The pulp was examined microscopically in the unbeaten state (C.S.f. 674 ml.) and at two stages of beating (C.S.f. 387 and 296 ml.). It was found that as beating progressed, tracheids with incipient rupture at the nodes, as shown in Figs. 15 and 16, became increasingly common. Concurrently, the fraction of fragments between 0.2 and 0.4 mm. in length increased.

The development of tracheids with partially rupture walls (hinge-joints) with beating was previously noted in measuring fiber flexibility (*1*). In that paper, it was also pointed out that some of the joints acted as "knee-bends" which were capable of bending in one direction and not the other. Figures 15 and 16 show how knee-bends might be observed in tracheids in which only part of the cell wall has been ruptured.

Tracheid length determinations were also conducted by measuring the lengths of about 400 tracheids. Ray cells were omitted in the sampling, since the tendency of these thin-walled cells to disintegrate during beating was found to present a misleading representation of tracheid shortening. The results of the length measurements are shown in Fig. 17. The data are presented as the distributions, in tracheid length of samples, normalized to a constant total tracheid length (approximately equal weights of pulp). A sharp maximum between 0.2 and 0.4 mm. in length distributions develops with progressive beating. The increase in height of the peak in this length increment suggests that the shortening process is not merely one of random rupture since this would be expected to produce a movement of the peak toward the left. These results are supported by the recent data for softwoods of Nordman and Niemi (*11*), which if plotted on the same basis as Fig. 17 also show a sharp maximum between 0.1 and 0.5 mm. in the length distribution of spruce sulfite and spruce and pine kraft pulps. It is also significant that Nordman and Niemi's results for the change in fiber length of birch pulps follow much more closely the pattern expected for random rupture, as one would expect for hardwood fibers which do not appear to have discretely spaced weak points.

These results imply that failures of the cell wall in softwood pulp tracheids at the nodes, whether through swelling or repeated flexing and stressing in the beating zone, contribute significantly to what is commonly, but perhaps loosely, termed "cutting" in the beater. The results also emphasize that the application of random rupture theory as a means to predict fiber shortening with beating is not applicable to softwoods, although it may have some validity for hardwoods.

DISCUSSION

Although the origin and nature of the nodes require further elucidation, it is in order to make some speculations on the basis of the present results.

It appears from photomicrographs in polarized light that the nodes are primarily manifestations of damage to the S_2 layer of the cell wall. Since the S_2 layer is many times thicker than the S_1 layer which surrounds it (S_2 is between 20 and 60 times thicker than S_1 in dried, delignified tracheids) (*5*), S_2 must contribute most to the rigidity of the tracheid. S_2 must therefore be especially vulnerable under the bending stresses to which the tracheids are subjected during disintegration of the cooked chips. Furthermore, bending of the tracheids is most likely to occur at the points where the tubular structure of the cell wall has been indented by the presence of ray cells in the wood. This offers a simple explanation to the observed coincidence of nodes and ray crossings.

It is possible that after repeated flexing of the tracheids, S_2 has been thoroughly disrupted at the nodes, but that the tracheids are still held together by the thinner and therefore more elastic S_1 sheath. During the beating process, S_1 is progressively disrupted, probably by the combined action of abrasion against other tracheids and by stresses generated by the swelling of S_2. Once S_1 has been broken, rupture will then occur at the points at which S_2 has already been damaged, i.e., at the nodes.

The absence of nodes in hardwood fibers may be attributed directly to the gross morphology of the wood, but further work is required to clear up this point.

Additional quantitative measurements of the extent to which tracheids are weakened by the presence of nodes, and diligent microscopic work to achieve a better understanding of the nature of the damage to the cell wall are required. It is only through such further studies that the full significance of nodes, to the pulping and papermaking processes, can be established.

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Determination of Wax in Paper

WILLIAM L. MORROW

A simplified method is recommended for the determination of the wax content of paper, in which three successive 1-min. extractions are made in weighing bottles, using 1,1,1-trichloroethane as the solvent. Experimental data are presented to show that extraction with this simple apparatus gives results equivalent to those obtained with Underwriters' extractors, and that the short extraction time is just as efficient as extraction periods of many hours. The recommended solvent is less toxic than carbon tetrachloride and is shown to be just as effective as the latter.

TWO STANDARD methods are available for the determination of wax in waxed papers, TAPPI Standard T 405 m-45 (*1*) and the method of Interim Federal Specification UU-B-0050 (*2*). Information on a comparison of the two methods is not available in the literature. Both methods specify extraction times that are very long, in view of the solubility of waxes in nonpolar solvents.

The objectives of this work are:

1. To compare a modified TAPPI Standard T 405 m-45 with the method of Interim Federal Specification UU-B-0050, for waxed papers.
2. To investigate the effect of time and the number of extractions.
3. To consider the possibility of substituting 1,1,1-trichloroethane for carbon tetrachloride in TAPPI Standard T 405 m-45.

MATERIALS

Six samples of commercial waxed papers were selected for testing. Some were obtained from the manufacturers and some were bought on the open market. Samples numbers 1 through 4 are waxed sandwich bags. Samples numbers 5 and 6 are waxed paper rolls designed for home use. The papers range in wax content from about 15 to 22%.

METHODS

TAPPI Standard T 405 m-45 specifies extraction in a Soxhlet or in an Underwriters' extraction cup with carbon tetrachloride for 6 hr., evaporation of the solvent and extraction of the residue with petroleum ether. The residue after the evaporation of the petroleum ether extract is considered to be the wax content of the specimen.

In this work 1,1,1-trichloroethane was substituted for carbon tetrachloride. The petroleum ether extraction was omitted and the residue, after evaporation of the 1,1,1-trichloroethane, was weighed. The wax content of the specimen was determined from the weight of this residue and also from the loss in weight of the paper.

In the Federal Specification the specimen is extracted, in a weighing bottle at room temperature,

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Table I. Determination of Wax Using a Modified TAPPI Method

Reported as a Percentage of the Original Weight of the Waxed Paper

Sample number	*Loss in weight of paper,*[a] *%*	*Std. deviation*	*Weight of extract,*[a] *%*	*Std. deviation*
1	16.1	0.2	15.6	0.1
2	20.4	0.1	21.6	0.3
3	15.5	0.1	15.4	0.4
4	19.5	0.7	18.7	0.6
5	22.5	0.4	21.2	0.2
6	19.3	0.4	18.0	0.3

[a] Each value is the average of three determinations.

Table II. Determination of Wax Using Interim Federal, Specification Method

Reported as a Percentage of the Original Weight of the Waxed Paper

Sample number	*Loss in weight of paper,*[a] *%*	*Std. deviation*	*Weight of extract,*[a] *%*	*Std. deviation*
1	15.7	0.2	15.9	0.2
2	20.2	0.2	19.9	0.2
3	15.0	0.4	15.2	0.4
4	18.9	0.4	18.6	0.4
5	22.4	0.3	22.3	0.2
6	18.4	0.5	18.2	0.5

[a] Each value is the average of three determinations.

Table III. Comparison of CCl_4 and CH_3CCl_3 in the Determination of Wax Using the Federal Specification Method

Sample number	*Loss in weight of paper,*[a] *%*	
	CCl_4	CH_3CCl_3
1	15.0 (0.2)	15.1 (0.3)
2	19.1 (0.3)	20.0 (0.3)
3	14.6 (0.6)	14.4 (0.2)
4	17.8 (0.2)	18.5 (0.2)

[a] Each value is the average of the three determinations. The numbers in parantheses are standard deviations.

Table IV. Effect of Time of Extraction Using Underwriters' Extraction Cups

Sample number		*Time, hr.* 1	2	3	4	5	6
3	Wax from dewaxed paper, %	15.4	15.2	15.3	14.9	15.4	5.7
	Wax from extract, %	15.1	15.3	15.2	14.8	15.4	15.5
		Time, min. 15	30	45	60	75	90
5	Wax from dewaxed paper, %	22.2	23.3	22.0	22.5	22.5	23.3
	Wax from extract, %	22.2	22.2	22.0	22.7	22.5	23.4

Table V. Effect of Shorter Time Using Federal Specification Method

Sample number		Time, hr. 1.5	2	3	4.5	6	7.5
3	Wax from dewaxed paper, %	14.6	...	15.2	14.6	15.5	15.2
	Wax from residue, %	15.3	...	15.2	15.3	15.9	15.7
5	Wax from dewaxed paper, %	22.6	22.5	22.5	22.0	22.0	22.1
	Wax from extract, %	22.6	22.4	22.4	21.9	21.8	22.1

with two changes of 1,1,1-trichloroethane, one for 16 and one for 7 hr. The loss in weight of the specimen is taken as its wax content. In this work the wax content was also determined by weighing the residue after evaporation of the combined extracts.

RESULTS AND DISCUSSION

Data presented in Tables I and II for the modified TAPPI Standard method and the Federal Specification method, respectively, are the average of three determinations. Good agreement was obtained between the wax content calculated from the loss in weight of the paper and the wax content from the weight of the extract. The fact that the wax content from the loss in weight of the paper is usually slightly higher, as shown in Table I, might be attributed to loss in moisture. A comparison of the wax content found from the samples in Tables I and II shows good agreement also between the modified TAPPI method and the Federal Specification method.

Data presented in Table III show a comparison of carbon tetrachloride and 1,1,1-trichloroethane made by McLeod (*3*) using the Federal Specification method. The results on the four samples are the average of three determinations. The experimental data show that 1,1,1-trichloroethane is just as effective as carbon tetrachloride for the extraction of wax.

To investigate the effect of time on the extraction in the determination of wax, samples numbers 3 and 5 were chosen because they represent the lowest and the highest wax-content values, respectively. Table IV shows the effect of the time of extraction on these two samples. A fresh specimen was used for each extraction period. Data presented in Table IV were obtained using Underwriters' extraction cups. This table shows that the extraction of sample number 3 for 1 hr. compares very favorably with the 6-hr. extraction. There is very little or no change in the 1- to 6-hr. period. In comparing sample number 5 in Tables IV and I, it is seen that an extraction of 15 min. compares well with the 6-hr. extraction. The change in per cent wax between the 15-min. and the 6-hr. period is insignificant. Four extraction cycles occurred during the 15-min. period.

Data presented in Tables V and VI were obtained using a modification of the Federal Specification method. A fresh specimen was used for each extraction period in Table V. The percentage of wax in Table V for the 1.5-hr. extraction of samples numbers 3 and 5 shows good agreement with the results of 23-hr. extractions, given in Table II. This finding led to the experiments reported in Table VI. For this work, one test specimen for each sample was used repeatedly. Evaporation and weighing were done after each extraction and each subsequent extraction was added to the original extract. The per cent wax from the three 1-min. extractions shown in Table VI compares very well with the 23-hr. extractions of Table II except for sample number 4 where the difference amounted to about 10%.

Table VI. Effect of Shorter Time Using Federal Specification Method

Sample number	Number of one-minute extractions: 1		2		3	
	Wax from weight of dewaxed paper, %	Wax from weight of extract, %	Wax from weight of dewaxed paper, %	Wax from weight of extract, %	Wax from weight of dewaxed paper, %	Wax from weight of extract %
1	15.3	14.9	15.4	15.2	15.4	15.2
2	20.1	20.4	20.9	20.8	20.9	20.6
3	14.4	14.2	14.8	14.7	14.8	14.8
4	17.0	16.6	17.2	16.8	17.2	16.8
5	21.6	21.2	22.0	21.6	21.9	21.7
6	18.5	17.9	19.1	18.6	19.1	18.7

Table VII. Effect of Number of Extractions Using Underwriters' Extraction Cups

Sample number	Number of extractions: 1		2		3	
	Wax from weight of dewaxed paper, %	Wax from weight of extract, %	Wax from weight of dewaxed paper, %	Wax from weight of extract, %	Wax from weight of dewaxed paper, %	Wax from weight of extract, %
1	15.6	15.2	15.9	15.7	16.1	15.8
2	20.0	19.8	20.4	20.2	20.5	19.8
3	15.1	14.8	15.1	15.2	15.1	15.1
4	19.1	18.5	19.4	18.8	19.5	18.6
5	21.3	21.1	21.6	21.4	21.7	21.2
6	18.6	18.0	19.1	18.4	19.3	18.4

The work reported in Table VII was done for correlation with the work in Table VI. The Underwriters' extraction cups were used for extraction. The extract and test specimen were treated the same as in Table VI. The per cent wax from the third extraction compares well with the per cent wax in Table I. The specimen was used repeatedly, and fresh solvent was used for each subsequent extraction. The wax content values presented in Tables VI and VII are similar, but the

analysis time is shorter for the work in Table VI than in Table VII. Simple and easy-to-obtain apparatus is used for the analysis in Table VI.

CONCLUSIONS

Wax-content data presented in this paper show that the TAPPI method and the Interim Federal Specification method gave corresponding values on six commercial waxed papers.

The time of analysis can be greatly reduced since most of the wax is removed in one extraction by either method.

1,1,1-Trichloroethane is a preferable alternative for carbon tetrachloride in TAPPI Standard T 405 m-45. Carbon tetrachloride is less desirable as it is more toxic than 1,1,1-trichloroethane.

The work presented in Table VI represents a modification of the method of Interim Federal Specification UU-B-0050. The wax-content values obtained after three 1-min. extractions are satisfactory and compare well with the values from the 23-hr. extractions. The apparatus is simple and easy to obtain, and the time of analysis is short. The modified method is recommended for an interlaboratory study as a basis for revision of TAPPI Standard T 405 m-45.

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An Analysis of Drying Curves of Cellulose Fibers

KARL LAUER

An analysis of drying curves was attempted in order to establish characteristics of various rayon-grade cellulose fibers. A study of the influence of controllable variables upon drying rates resulted in a satisfactory procedure. The log drying rate vs. moisture content curves give linear portions, the intercepts of which are found at moisture contents which are in good agreement with otherwise-determined quantities of hydrogen-bonded and solution water, respectively. Using this treatment, characteristics of fibers could be established. It was also possible to show that diffusion inside the fibers is the rate-determining factor and is determined by the structure of intercrystalline regions. The slopes of the rate equations give an indication of the resistance towards diffusion from the interior of the fibers. It was found that rayon-grade wood pulps show similar drying behavior according to the process of preparation, notwithstanding whether they originate from hardwoods or softwoods.

The relationship of cellulose fibers to water is determined by the submicroscopic structure of the fibers. Two classes of water sorbed on by fibers are considered: (1) bound water (hydrate-, hydrogen-bonded water) the bonding energy of which is large, and (2) water, the vapor pressure of which is only slightly lowered (solvent, swelling, multilayer water) (*1*). In general the fiber–water relationship under given conditions will depend on the size and quantities of crystalline regions and upon the lateral order distribution. Any change of these variables, caused by physical or chemical treatments will influence the system fiber–water.

Drying curves of fibers should give indications of differences in structure, characteristic for definite fibers. Some factors governing the rate of drying are external to the fibers: such as temperature, relative humidity, and the effective velocity of the drying atmosphere. For a given drying device these factors can be maintained constant. Other factors, inherent in the sample, are the subject of this study.

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MATERIALS AND EXPERIMENTAL PROCEDURE

The rate of drying from a wet surface is expressed approximately by the equation:

$$-dw/dt = RA(H_s - H_a)$$

where

w = weight loss
t = time
A = surface area
R = constant
H_s = saturated humidity of the surface of the solid
H_a = relative humidity of surrounding atmosphere

To obtain values characteristic for specific fibers, numerous experiments were made to determine the exact working conditions necessary in order to guarantee reproducible values. The following procedure was found the most reliable.

Materials

Cotton Acala 1517, termed C-55, was hand-picked and immediately immersed in water. After extraction with a mild detergent the samples were kept in distilled water.

Two samples of viscose-grade cotton linters were taken after the bleaching step, never dried and kept in distilled water.

Viscose-grade wood pulps, obtained in machine-dried sheets were disintegrated in distilled water. Table I gives characteristics of these fibers. Never-dried viscose rayon yarn was obtained in three forms:

V-A, taken directly after the spinneret and washed in cold water.

V-B, the same rayon after 48% stretching.

V-C, the same rayon after 78% stretching.

Procedure

The fibers used were either never completely dried (termed wet), air-dried or dried at 105°C. *in vacuo*

Table I. Characteristics of Celluloses Used

Code	Fiber	Species	Treatment	D.P.	Cellulose: alpha-	Cellulose: beta-	Cellulose: gamma-	Hot 10% KOH soluble	Ether-soluble	Ash
C-55	Cotton	Acala 1517	None	3860	..	..	..	..	..	..
L-I	Linters	.....	k-b[a]	890	98.6	1.0	0.2	4.2	0.06	0.05
L-II	Linters	.....	k-b	880	98.8	1.1	0.2	4.7	0.07	0.05
HW-I	Wood pulp	Mixed hardwoods	pSa[b]	615	94.9	2.2	2.9	7.3	0.08	0.07
HW-II	Wood pulp	Mixed hardwoods	pSa	965	97.5	1.5	1.0	4.8	0.03	0.05
LP-p	Wood pulp	Loblolly pine	pSa	1075	96.6	1.3	2.1	4.4	0.01	0.06
LP-S	Wood pulp	Loblolly pine	Si[c]	1656	95.9	1.4	2.7	7.1	0.10	0.11
Sp	Wood pulp	Spruce	Si	1041	91.9	4.3	3.8	13.2	0.13	0.05
H	Wood pulp	Hemlock	Si	635	93.4	4.6	2.0	6.2	0.09	0.09
PS	Wood pulp	*Pinus sylvestris*	Si	745	92.3	4.7	3.0	7.8	0.10	0.05

[a] k-b = kiered and bleached.
[b] pSa = prehydrolyzed sulfate.
[c] Si = sulfite.

over P_2O_5 (termed dry). Dried fibers were immersed in distilled water for at least 24 hr.

A quantity of fiber, corresponding to a sheet of about 4 g.s.m., was disintegrated and deposited in a sheet-forming apparatus on a 100-mesh screen. Excess water on the screen was removed by pressing on blotting paper. The screens were placed on a steel-wire frame which was fixed to a balance. The balance was arranged on top of a convection oven, regulated by two thermoregulators to constant temperature ±1°C. The samples were hanging in the center of the oven, with one thermoregulator above, the other below the samples.

Time for definite weight losses was measured with electric stopwatches. At the end of the run the exact dry weight of the sample was determined and the moisture contents at various stages of drying calculated. The rate values $-dw/dt$ are given on the basis of 1 g. dry fiber as weight loss in grams per minute.

RESULTS

Analysis of Curves

The usual way of expressing experimental results is by a rate-of-drying curve (*2*). With well-opened cellulose fibers curves as shown in Fig. 1 are obtained. After a constant-rate period the rate falls concave toward the abscissa to zero moisture. If the moisture contents are calculated on a wet basis, sigmoid curves result.

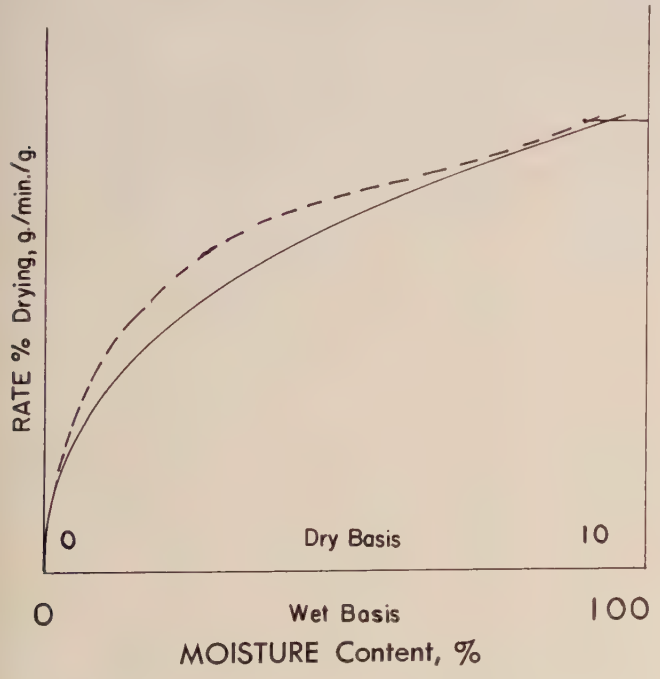

Fig. 1. General form of curves of drying rates vs. moisture contents on dry basis (——) and on wet basis (– – –)

Figure 2 shows that plotting log $-dw/dt$ versus moisture content on a dry basis results in a curve, whereas the plot against moisture content on a wet basis gives straight lines. Only log $-dw/dt$ versus log moisture content on a day basis gives a straight-line relationship.

A decision on which of the treatments of experimental data gives characteristics comparable with otherwise-determined facts was possible from Table II. Here amounts of bound-and solution water, determined in different ways, are compiled from the literature.

An analysis of the curve in Fig. 2B gives four rates and three intercepts:

1. A constant rate of drying at the beginning.
2. A linear falling-rate period initially.
3. An intercept between (1) and (2), designated X_R.
4. A second linear falling-rate period.
5. An intercept between (2) and (4), termed X_S.

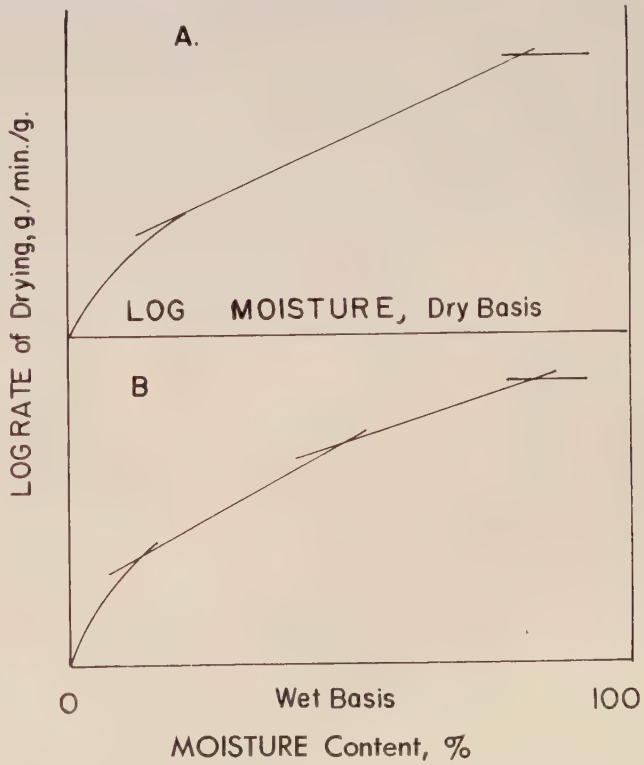

Fig. 2. General form of curves of log rate of drying vs. moisture content on wet basis, and vs. log moisture content on dry basis

Table II. Bound-and Solution Water Determined by Different Methods

Values are per cent water on wet basis

	Cotton and linters		Mercerized cotton		Wood pulps		Rayon	
	b	*s*	*b*	*s*	*b*	*s*	*b*	*s*
Nonsolvent water (*3, 4, 5*)	5–6	..	9–12	..	6–8	..	10–12	..
Moisture isotherms								
Sorption (*6*)	3.5–4.7	..	..	..	..	..	12.7	22.0
Desorption (*7*)	8.9	..	..	..	..	..	17.0	28.2
Nonfreezing water (*8, 9*)	4.3–6.4	19–20	12	..	..	..	19.0	..
Drying (*10, 11, 12*)	..	26–28	..	..	..	..	..	38–40
X_H and X_S(desorp.)	5.1	18.6	10.1	28.8	6–8	22–25	14.0	35–40
(sorpn.)	4.7	19.8	..	..	..	..	11.5	26–30
calcd. from drying curves								

6. A rate, curved toward zero moisture.
7. An intercept between (4) and (6), termed X_H.

Comparing the values of intercepts with otherwise-determined quantities of bound-and solution water, as seen in Table II, there is no doubt that X_H gives the amount of bound- or hydrate water whereas X_S gives the amount of solution water and bound water together. $X_S - X_H$ is the quantity of water taken up as solution or multilayer water after free hydroxyl groups have been saturated. The intercept X_R should correspond with the fiber saturation point or swelling value or moisture-retaining value. As will be seen later it is not possible to consider this value, as determined from drying curves, as characteristic for fibers.

Drying Rate and Shape of Sample

The shape of the sample to be dried has a great influence on the rate of drying as it determines the free surface area as well as the form and size of capillaries and cavities between individual particles. In order to obtain comparable characteristics of fibers it is necessary to open up samples in such a way that the true free surface of the fibers is exposed to a maximum to the drying atmosphere.

The shape influence was satisfactorily eliminated by forming handsheets of about 4 g.s.m. dry fiber. Cotton could not be formed into sheets but was combed on a card to a loose thin band. With practice reproducible results were obtained.

Figure 3 shows the influence of sheet weight on drying rates for samples of 80% water content. The most important observation from these experiments is the fact, that the rate of drying of all types of high-alpha pulps, linters, and even unbleached cotton are found on one single curve during the first step of drying. The only exception is a bleached low-alpha paper pulp. That means that in the beginning of drying of a wet fiber, the rate of drying is independent of the fiber or the fiber history, but only depends on the weight of the sheet and the temperature.

At very low sheet weights, i.e., below 3 g.s.m. the rate of drying rises asymptotically, so that the values observed are in error and the determination of a fiber saturation point is impossible. The constant rate does not show, because the evaporation of water present in the screen overlaps the evaporation of water from the fibers. Our measurements were therefore made with sheets of about 4 g.s.m., in which region a constant

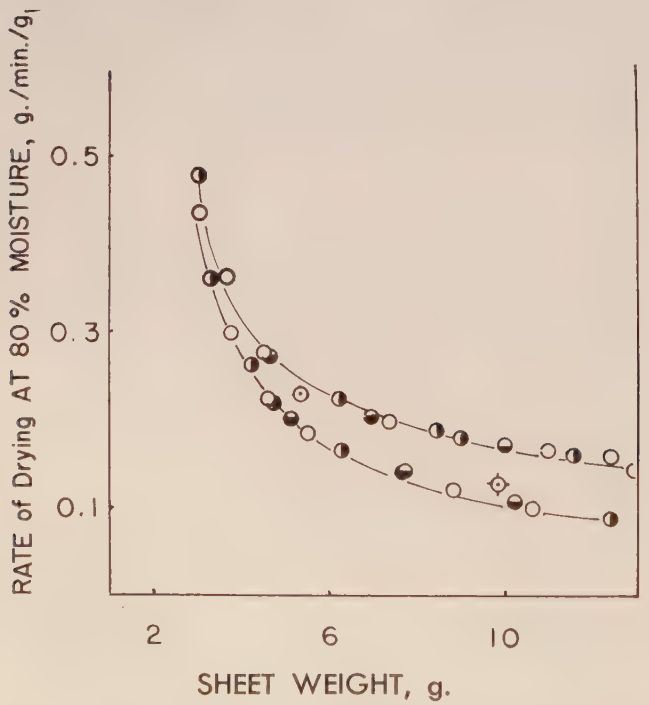

Fig. 3. Rate of drying of various cellulose fibers at 80% moisture content vs. sheet weight

◑—Cotton linters; ○—prehydrolyzed sulfate rayon pulps; ◒—sulfite rayon pulps; ⊙—bleached, low-alpha paper pulp.

Table III. Drying Data for Cotton Linters at 32.4°C.

Sample weight, g.	*Weight loss, g.*	*Time, sec.*	*Moisture, %*	*Rate Exptl.*	*Rate Calcd.*	*Deviation, %*
23.00	2.00	630.6	95.8	0.1884		
21.00	2.00	688.2	95.4	0.1728		
19.00	2.00	710.2	94.9	0.1675		
17.00	2.00	717.4	94.4	0.1658		
15.00	2.00	720.2	93.7	0.1650		
13.00	2.00	719.1	92.8	0.1656		
11.00	2.00	719.9	91.6	0.1652		
9.00	2.00	720.2	89.9	0.1650	0.1649	0.06
7.00	2.00	759.1	87.4	0.1575	0.1566	−0.57
5.00	2.00	798.4	83.8	0.1488	0.1474	0.95
4.00	1.00	457.1	77.6	0.1300	0.1314	−1.07
3.00	1.00	512.0	71.1	0.1160	0.1165	−0.43
2.40	0.60	353.7	62.6	0.1007	0.0998	0.92
2.00	0.40	279.4	54.1	0.0851	0.0853	−0.31
1.80	0.20	156.1	46.9	0.0762	0.0761	0.13
1.60	0.20	191.2	40.6	0.0622	0.0635	−2.02
1.50	0.10	98.9	34.9	0.0601	0.0599	0.33
1.40	0.10	107.1	30.4	0.0555	0.0553	0.36
1.30	0.10	118.1	25.2	0.0503	0.0501	0.04
1.26	0.04	51.4	21.1	0.0463	0.0464	−0.20
1.22	0.04	56.3	18.6	0.0423	0.0424	−0.24
1.18	0.04	65.7	15.9	0.0362	0.0360	0.56
1.14	0.04	76.3	12.9	0.0312	0.0310	0.64
1.12	0.02	43.8	10.6	0.0271	0.0273	−0.74
1.10	0.02	47.2	9.0	0.0252	0.0250	0.40
1.08	0.02	52.3	7.4	0.0227	0.0230	−1.30
1.06	0.02	65.4	5.6	0.0182	0.0208	−12.5
1.04	0.02	86.6	3.8	0.0137	0.0189	−27.5
1.03	0.01	60.3	2.4	0.0099	0.0175	−43.4
1.02	0.01	145.1	1.6	0.0041	0.0168	−75.6
1.0101	..	..	0.0	..	..	..

Constant rate: = 0.1656 g./min./g.
1st rate equation: log rate = −0.702 − 0.008 (100-moisture)
2nd rate equation: log rate = −0.537 − 0.0235 (100-moisture)
X_R = 90.1% moisture.
X_S = 20.1% moisture.
X_H = 7.4% moisture.

Table IV. Temperature and Drying Rate

Temp., °C.	X_R	Constant rate, g./min./g.	Log 1st rate	Rate at 80% moisture	X_S	Log 2nd rate	Rate at 20% moisture	Bound water, mol.
L-I								
42.0	12.4	0.2031	−0.594 − 0.008 (100-M)	0.1760	20.1	−0.644 − 0.0235 (100-M)	0.05808	0.72
65.0	12.2	0.3194	−0.398 − 0.008 (100-M)	0.2764	19.8	−0.844 − 0.0235 (100-M)	0.09204	0.71
93.5	12.3	0.4782	−0.222 − 0.008 (100-M)	0.4150	20.3	−1.011 − 0.0235 (100-M)	0.1352	0.72
101.5	..	None	−0.186 − 0.008 (100-M)	0.4508	20.0	−1.042 − 0.0236 (100-M)	0.1424	0.72
105.0	..	None	−0.163 − 0.008 (100-M)	0.4755	20.0	−1.077 − 0.0235 (100-M)	0.1532	0.73
115.0	..	None	−0.086 − 0.008 (100-M)	0.5679	20.1	−1.152 − 0.0235 (100-M)	0.1871	0.72
128.0	..	None	−0.028 − 0.008 (100-M)	0.7378	19.8	−1.255 − 0.0234 (100-M)	0.2416	0.72
LP-S								
28.0	9.0	0.2075	−0.611 − 0.008 (100-M)	0.1695	22.8	−0.254 − 0.0191 (100-M)	0.05321	0.77
32.5	9.0	0.2388	−0.550 − 0.008 (100-M)	0.1950	23.1	−0.304 − 0.0191 (100-M)	0.05970	0.76
42.0	9.1	0.3063	−0.441 − 0.008 (100-M)	0.2506	23.0	−0.406 − 0.0190 (100-M)	0.07699	0.78
51.0	9.0	0.3681	−0.362 − 0.008 (100-M)	0.3008	23.6	−0.486 − 0.0191 (100-M)	0.09078	0.77
57.5	8.9	0.4138	−0.312 − 0.008 (100-M)	0.3374	23.3	−0.539 − 0.0191 (100-M)	0.10250	0.77

rate is observed and differences in these can be verified in parallel determinations.

Accuracy of Determinations

Table III gives the results of an experiment with a cotton pulp at 32.4°C., as an example. The deviations of experimental rate values from calculated ones, using rate equations calculated by means of the method of least squares, are about ±3% in the same experiment and about ±5% for two parallel series of experiments.

Drying Rate and Temperature

In Table IV characteristics, calculated from drying curves, are compiled for a linters and a pulp sample. These characteristics are representative of the influence of the temperature of the drying air on drying rates.

Practically identical intercepts are obtained at temperatures between 28 and 128°C., indicating that for a given fiber the quantity of bound water and solution water, reached from the wet end, are independent of temperature and may be considered true characteristics of the fiber.

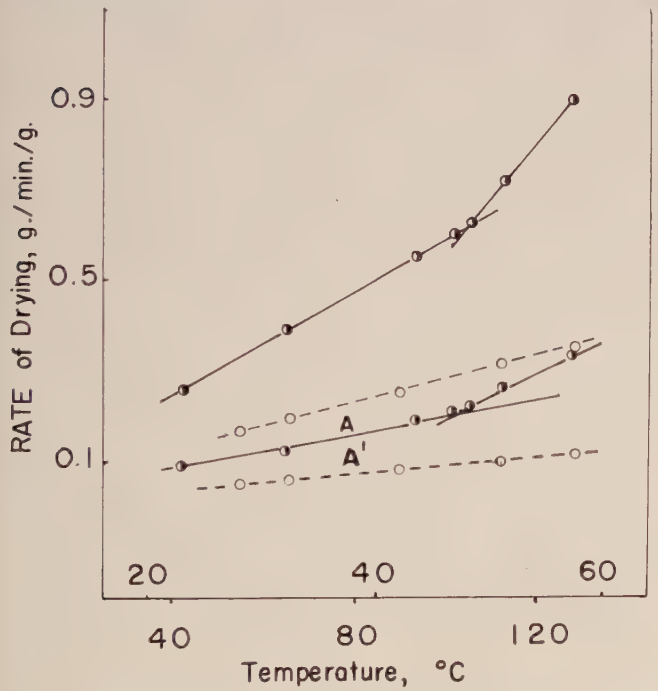

Fig. 4. Relationship between drying rates at 20% (upper curves) and 80% moisture content (lower curves) and temperature

●—Cotton linters (40–130°C.); ○—prehydrolyzed sulfate pulp (28–58°C.).

Again the determination of a fiber saturation point is impossible and at higher temperatures no constant rate is observable because evaporation from the screen and from the fiber overlap.

Figure 4 shows that the rates of drying at comparable conditions—80% and 20% moisture contents were chosen arbitrarily in Table IV—give straight-line relationships at temperatures below 100°C., indicating that drying is governed by diffusion of water from the interior of the fibers to the surface of vaporization.

At temperatures above 100°C. again a linear relationship with temperature is observed, but the slope has become steeper and the two straight lines is intersect at about 102°C.

The rate equations in Table IV display unchanged slopes at different temperatures. In the graphs the lines run parallel. The influence of the temperature on drying rates is found in the first terms of the equations.

DISCUSSION

If drying rates, determined as described, are characteristic for specific fibers, than intercepts and slopes have to follow a definite pattern even if the absolute values established depend on the drying device and its definite conditions.

The cotton sample which was never dried and could be dried at 50% R.H., and also completely, was used to correlate drying data with the well-known changes in the system fiber–water due to drying. Table V shows the results.

The never-dried sample showed only one linearly falling rate and 3.04 mol. of bonded water. Drying at room temperature at 50% R.H. made a second falling rate unmistakably visible. The bound-water content dropped to 0.56 mol., and the solution water to 1.01 mol. These results could be verified from drying data obtained with the three rayon samples, which show the same behavior when dried (Table V).

In accordance with the observations of Hermans (*13*) it could also be verified that differences in the fiber–water system due to orientation are small, but still observable. The greatest differences appear in the amounts of solution water, which drop from 5.3 to 5.0 to 3.34 mol. with increasing orientation.

Table VI show rate-of-drying data for air-dried and machine-dried fiber samples. X_R as well as constant-rate values have been excluded from the table because it was found impossible to obtain comparable results which would permit the establishment of charac-

Table V. Influence of Fiber History on Drying Rates

Fiber history	Log 1st rate	Rate at at 80% g./min./g.	X_S	Log 2nd rate	Rate at 20% moisture	Bound water, mol.
Cotton						
Never dried	−0.569 − 0.008 (100-M)	0.1865	..	.....	...	3.04
Air-dried	−0.743 − 0.008 (100-M)	0.1250	15.0	−1.109 − 0.0298 (100-M)	0.05334	0.56
Dried	−0.768 − 0.008 (100-M)	0.1180	17.4	−1.148 − 0.0312 (100-M)	0.04498	0.47
Rayon unstretched:						
Never dried	−0.362 − 0.008 (100-M)	0.3004	..	.....	...	2.60
Dried	−0.283 − 0.008 (100-M)	0.3606	41.4	−0.322 − 0.0183 (100-M)	0.07228	0.97
Rayon, 48% stretched						
Never dried	−0.365 − 0.008 (100-M)	0.2987	..	.....	...	2.52
Dried	−0.333 − 0.008 (100-M)	0.3213	40.0	−0.273 − 0.0181 (100-M)	0.06682	1.00
Rayon, 78% stretched	−0.414 − 0.008 (100-M)	0.2664	..	.....	...	2.57
Dried	−0.495 − 0.008 (100-M)	0.2213	33.5	−0.549 − 0.0237 (100-M)	0.04508	1.16

teristics. From these measurements the following conclusions can be drawn:

1. The first falling-rate periods have identical slopes for all fibers, even for the unbleached cotton, the low-alpha paper pulp and the nonstretched and stretched rayon samples. But, whereas, this rate is practically identical for all the viscose-grade wood pulps—they may be prepared from cotton linters, softwoods, or hardwoods by acid or prehydrolysis–alkaline processes—

content X_S all the free water is removed and solution water begins to diffuse. This water has a lower vapor pressure, as established by freezing-point lowering, (*9*), which would explain the retardation of evaporation. If not, during the second falling-rate period the slopes of the log $-dw/dt$ vs. moisture curves in Fig. 4 would be different for different fibers. We must therefore consider that diffusion from the interior is determined by the structure of the intercrystalline regions too.

Table VI. Drying Data for Cellulose Fibers

4 g.s.m. at 32.5°C.

Fiber	D.P.	Regain, %	Log 1st rate	Rate at 80% moisture	X_S	Log 2nd rate	Rate at 20% moisture	Bound water, mol.
			Cotton					
C-55	3860	4.16	−0.743 − 0.008 (100-M)	0.1250	15.0	−1.109 − 0.0298 (100-M)	0.05334	0.56
L-I	890	3.91	−0.702 − 0.008 (100-M)	0.1373	20.0	−0.538 − 0.0235 (100-M)	0.04571	0 72
L-II	880	3.83	−0.714 − 0.008 (100-M)	0.1337	18.7	−0.782 − 0.0264 (100-M)	0.04677	0.71
			Wood Pulps					
Prehydrolyzed sulfate								
HW-I	965	4.55	−0.701 − 0.008 (100-M)	0.1380	20.5	−0.404 − 0.0219 (100-M)	0.04508	0.70
HW-II	615	4.04	−0.700 − 0.008 (100-M)	0.1377	21.8	−0.519 − 0.0235 (100-M)	0.04365	0.72
LP-p	1075	4.14	−0.698 − 0.008 (100-M)	0.1387	20.4	−0.352 − 0.0212 (100-M)	0.04539	0.68
Sulfite								
LP-S	1656	4.33	−0.702 − 0.008 (100-M)	0.1373	23.2	−0.151 − 0.0191 (100-M)	0.04208	0.77
Sp	1041	4.45	−0.701 − 0.008 (100-M)	0.1377	23.8	−0.183 − 0.0196 (100-M)	0.04539	0.78
H	635	4.06	−0.700 − 0.008 (100-M)	0.1380	22.5	−0.253 − 0.0203 (100-M)	0.04276	0.71
PS	745	4.28	−0.700 − 0.008 (100-M)	0.1380	22.9	−0.156 − 0.0191 (100-M)	0.04246	0.76
Paper pulp	1680	7.81	−0.790 − 0.008 (100-M)	0.1122	..	.....	...	1.47
			Rayon (Viscose)					
R-A	385	10.8	−0.283 − 0.008 (100-M)	0.3606	41.3	−0.322 − 0.0183 (100-M)	0.07228	0.96
R-B	385	10.8	−0.333 − 0.008 (100-M)	0.3213	40.0	−0.273 − 0.0181 (100-M)	0.06682	0.97
R-C	385	11.0	−0.495 − 0.008 (100-M)	0.2213	33.5	−0.548 − 0.0237 (100-M)	0.04509	1.16

the rates of the unbleached cotton, the paper pulp and the rayon samples are lower or higher, respectively.

2. The amounts of solution water found increases in the order cotton, linters, prehydrolyzed sulfate pulps, sulfite pulps, oriented rayon, nonoriented rayon. Paper pulp shows a different behavior.

3. The second falling rates vary remarkably, but there is a drop in the slopes from cotton to linters to prehydrolyzed sulfate pulps to sulfite pulps. Again it is the method of preparation and not the raw material used which determines the position of the pulp in Table VI.

4. The amounts of bound water found correspond with otherwise-determined quantities. In the first falling-rate period free water is vaporized as soon as it reaches the surface of vaporization by diffusion from the interior of the fibers. At a characteristic moisture

The slopes of the second rate curves indicate the resistance to diffusion, whereas the $(X_S - X_H)$ values give the quantities of solution water. As the two values vary in opposite directions the differences in rate may simply be caused by differences in concentration, considering the differences in quantities of amorphous chain elements. But they may also be caused by the specific arrangement of "amorphous" regions or molecular segments.

The linters samples differed only in their viscose filterability; L-I giving good-filtering, L-II poor-filtering viscoses. The drying data of the two linters show differences in rates and the second rate slopes which, for the poor-filtering linters, are found between those of unbleached cotton and the well-filtering linters. Results from one single comparison do not permit a decision on whether this indication of a more native structure is the reason for filterability behavior.

SUMMARY

Analyses of drying curves of high-alpha-cellulose fibers give characteristics which correspond to otherwise-established quantities of bound-and solution water. Three groups of fibers can be distinguished, depending on their chemical treatment.

These characteristics also give indications of the resistance to diffusion of water through the amorphous regions of fibers.

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Structural Changes During Aging of Alkali Celluloses

K. LAUER and H. CHAO-WU

Former observations of structural changes in cellulose fibers during aging has made a study of their drying behavior desirable. An analysis of drying rates gives the amounts of hydrogen-bonded and solution water. An analysis of the slopes of the log. rate vs. moisture curves gives indications of the intercrystalline fiber structure. A comparative study of celluloses, regenerated from alkali celluloses at various stages of aging, led to the establishment of a definite pattern of lateral order changes during aging. Drying-rate analyses, sedimentation volume, desorption and regain, in combination with x-ray diffraction analyses confirmed the formerly observed periodic structural changes, which could be related to size and organization of the ordered regions of the fibers.

During the aging of alkali celluloses structural changes occur which are caused by changes in crystalline regions, the decrease in absolute crystallinity or lateral order, and in crystallite size. These generally valid observations on natural fibers are understood by considering that swelling and incomplete rearrangements will produce such phenomena.

It had been observed, that celluloses recovered from alkali celluloses at various stages of aging show periodic changes of structural characteristics (*1*). From the drying curves of fibers characteristics can be derived which give an indication of intercrystalline order (*2*). This method was applied to cellulose fibers, obtained from alkali celluloses at various stages of aging.

PROCEDURE

The pulps used were industrial, machine-dried viscose-grade pulps. Their characteristics are compiled in Table I. The wood pulps were steeped for 60 min. in sheet form in 20 parts of 18.5% NaOH at 18 to 20°C., pressed to a press factor of 3.0 to 3.1, shredded immediately at 22 ± 1°C. for 2 hr. and the shredded alkali celluloses aged in closed containers on a roller at 20°C. Samples were taken at intervals.

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The linters pulps were steeped as slurry, but otherwise treated like the wood pulps. After definite periods of aging, samples were taken, disintegrated in water, filtered, washed with distilled water and determinations made immediately. Separate samples of alkali celluloses, corresponding to 20 g. cellulose, were taken at the same time and the sedimentation volume determined as described in reference (*1*).

The following determinations were made on wet samples:

1. Sedimentation volume.
2. Desorption at 20°C. and 40% R.H.
3. Drying curves on 4-g.s.m. samples at 32.4°C.

The following determinations were made on completely dry samples:

1. D.P. in cupriethylenediamine.
2. Regain at 20°C. and 40% R.H.
3. Sedimentation volume of 2-g. fiber, immersed in 250 ml. water.

All results given in the tables are averages of at least two independent determinations.

RESULTS AND DISCUSSION

In Tables II to VII results are compiled for six representative, industrial, rayon-grade pulps from linters and wood. In a preceding communication (*2*) it was shown that the amounts of hydrogen-bonded water and of solution water could be calculated from drying

Table I. Characteristics of Rayon-Grade Pulps Used

Fiber	*Species*	*Treatment*	*D.P.*	*Alpha-cellulose*
Linters	...	k-b[a]	890	98.6
Wood pulp	Loblolly pine	p-Sa[b]	1075	96.6
Wood pulp	Loblolly pine	Si[c]	1656	95.9
Wood pulp	Spruce	Si	1041	91.9
Wood pulp 1	Mixed hardwoods	pSa	965	97.5
Wood pulp 2	Mixed hardwoods	pSa	615	94.9

[a] k-b, kiered and bleached.
[b] p-Sa, prehydrolyzed sulfate.
[c] Si, sulfite. All pulps showed good filterability in mill operation and, with the exception of the mixed hardwood pulp 2, good spinnability.

curves, and that the falling rates are determined by diffusion rates. The characteristic differences in drying rates of natural fibers showed only in the second falling rates, the latter being therefore determined by the structural order of the fibers. For all fibers at different stages of aging identical first falling rates were established, which were identical also with the first rates of the original, nonmercerized fibers. This shows that the first falling rate is determined by diffusion of free water from coarse cavities of the fibers.

The System Fiber–Water From the Wet End

All determinations, made from the wet end of the system fiber–water, were made on completely swollen fibers and the moisture contents established correspond to desorption. For all six pulps, as for many others investigated, the sedimentation volume with its variations during aging runs parallel with desorption and the amount of hydrogen-bonded water. During aging of alkali celluloses the fibers not only show a decrease in viscosity, but the lateral order distribution changes in a definite pattern. This change of the fiber structure is independent of the nature of the raw material, of the method of preparation of the pulps, and of the D.P. of the original pulps. This follows because it has been established, without exception, that the highest sedimentation volumes are observed at a D.P. of 524 for linters and at D.P.'s between 454 and 472 for the wood pulps; which is in accordance with earlier observations that cotton and cotton linters show this sedimentation maximum at D.P.'s between 500 and 600, wood pulps at D.P.'s between 450 and 500 (*1*).

The experimental results show maxima of desorption, the drying rate at 20% moisture content, and the amount of bonded water at the same D.P.'s at which the highest sedimentation volume is found; whereas the amounts of solution water and the slope of the second falling drying rate curves show minima.

Cellulose fibers regenerated from alkali celluloses at varying degrees of aging, reach a structural arrange-

Table II. Aging of Cotton Linters Pulp

Determination	*Nonmercerized*	*Time of aging, min* 15	90	120	150	180	210	240	330	420
D.P.	890	715	584	569	524	501	480	448	420	362
Desorption, %	5.00	8.52	8.31	8.43	9.23	8.78	8.82	9.06	9.20	9.34
Regain, %	3.92	7.22	7.15	7.16	6.86	7.24	7.10	7.14	7.15	6.86
Sedimentation volume,[a] ml.										
Wet fibers	...	230	200	220	290	220	230	250	210	250
Dried fibers	...	56	58	60	49	51.5	63	61	61	51.5
Solution water, mol./C_6	1.55	2.95	2.07	2.09	1.34	1.87	1.85	1.59	1.61	1.63
H-bonded water, mol/C_6[b]	0.72	1.32	1.09	0.90	1.02	0.76	0.83	0.95	0.84	0.91
Drying rate at 20% moisture × 100	4.57	2.44	3.51	3.78	4.84	4.36	4.30	4.56	4.62	4.53
Second rate slope ×100	2.35	2.63	2.66	2.60	2.25	2.44	2.36	2.32	2.60	2.42
Diffraction peaks at $^1/_2$ max., $2\theta°$										
(002) plane	1.31	...	1.62	1.53	1.50	1.55	...	...	1.55	1.35
(10$\bar{1}$) plane	...	...	1.82	1.72	1.68	1.71	...	...	1.55	1.66
Resolution of peaks	g.[c]	...	g.	v. g.[d]	v. g.	v. g.	...	...	g.	

[a] Sedimentation volumes of wet and dried fibers are not comparable. [b] C_6 is glucose unit. [c] g. = good. [d] v. g. = very good.

Table III. Aging of Prehydrolyzed Sulfate Pulp from Southern Pines

Determination	*Nonmercerized*	*Time of aging, min.* 15	60	120	150	210	240	270	300	360	480
D.P.	1075	823	628	551	524	481	465	448	430	403	308
Desorption, %	5.31	8.67	9.29	8.78	8.38	9.00	9.63	9.47	9.15	9.08	9.05
Regain, %	4.14	7.38	8.18	7.82	8.08	7.92	8.30	8.04	8.44	8.08	8.01
Sedimentation volume, ml.											
Wet fibers	...	220	280	260	240	270	300	280	260	260	300
Dried fibers	...	65	63	64	65	66.5	64.5	67	68	70	82
Solution water, mol./C_6	1.64	3.28	2.16	1.57	1.38	1.78	1.10	1.63	1.25	1.64	1.25
H-bonded water, mol./C_6	0.68	2.16	1.61	1.03	0.96	0.88	1.07	0.92	0.94	0.83	1.13
Drying rate at 20% moisture ×100	4.54	3.57	3.65	4.37	4.49	4.13	4.86	4.81	4.64	4.30	4.44
Second rate slope ×100	2.12	1.42	1.86	2.09	2.25	2.28	2.13	2.18	2.27	2.82	2.30
Diffraction peaks at $^1/_2$ max., $2\theta°$											
(002) plane	1.76	...	1.78	...	1.62	...	1.55	1.59	1.65		
(10$\bar{1}$) plane	...	...	1.82	...	1.85	...	1.65	1.68	1.69		
Resolution	v. g.	...	g.	...	g.	...	v. g.	v. g.	g.		

Table IV. Aging of Southern Pine Sulfite Pulp

Determination	*Nonmercerized*	*Time of aging, min* 5	60	120	150	180	210	240	270	300	420
D.P.	1656	1406	732	601	562	523	506	484	460	445	338
Desorption, %	...	7.95	9.17	9.51	9.16	9.18	9.74	9.95	10.42	9.32	9.32
Regain, %	4.33	7.17	8.44	8.84	8.82	8.56	8.66	8.15	7.87	8.54	8.60
Sedimentation volume, ml.											
Wet fibers	...	200	320	300	260	240	250	290	315	250	310
Dry fibers	...	40.5	60.0	66.0	68	65.5	58	54	53	60	64
Solution water, mol./C_6	1.94	2.22	1.95	2.27	3.08	2.19	1.31	1.15	0.85	1.61	1.37
H-bonded water, mol./C_6	0.77	0.78	1.57	1.23	1.12	1.02	0.96	1.03	1.26	1.08	1.02
Drying rate at 20% moisture ×100	4.21	3.82	3.44	3.36	2.95	1.97	3.56	3.95	4.71	4.08	4.44
Second rate slope ×100	1.91	2.35	2.35	2.28	2.43	2.54	2.68	2.38	2.20	2.45	2.36
Diffraction peaks at $^1/_2$ max., $2\theta°$											
(002) plane	2.00	...	...	1.74	1.67	...	1.85	1.75	1.72	...	1.69
(10$\bar{1}$) plane	...	...	...	1.62	1.64	...	1.73	1.70	1.64	...	1.69
Resolution	v. g.	...	...	g.	g.	...	g.	v. g.	v. g.	...	g.

ment which, for rayon-grade pulps at definite D.P.'s, show maximum swelling as well as a maximum number of hydroxyl groups, available for hydrogen bonding; in short, a relatively open structure. The low slope of the second rate curve and the relatively high rate of drying in this region of moisture contents indicate the relative ease with which water can diffuse through the fiber. This does not necessarily mean that the fibers in this state contain small ordered and large disordered regions, because the amount of solution water is at a minimum.

In Figure 1 some of the changes in the fiber–water relationship are shown for a linters pulp, a prehydrolyzed sulfate, and a sulfite pulp from pine. It is obvious that there is good agreement of maxima and minima, independent of the methods of determination. In general the amount of water taken up by a fiber depends upon the lateral order distribution and upon swelling effects. In the case of never-dried fibers regenerated from alkali celluloses, swelling was complete and intercrystalline adsorption has to be considered. The analysis of drying curves should give a picture of the lateral order changes occurring during aging.

The System Fiber–Water From the Dry End

Differences in moisture regain have been attributed to differences in the size of crystals (*3*) and to different arrangements in the disordered regions (*4*). X-ray diffraction analysis of cellulose fibers have been applied, to characterize the lateral order (*5*). The peak width at half maximum diffraction is inversely proportional to the size of the ordered regions in the sample (*6*). The width of the peaks for the ($10\bar{1}$) and (002) planes of some of our samples has been calculated from diffractometer curves made for us by Dr. L. R. Parks, as described in reference (*5*), and are included in Tables II to VII. The charts all correspond to cellulose II with better-than-normal resolution of the ($10\bar{1}$) and (002) peaks, but differ in resolution between themselves. In the tables the degree of resolution is indicated as very good and good.

Comparison of the diffraction peaks obtained from powder samples of completely dried celluloses shows that the width of the peaks is smallest for samples which show the maximum swelling, if determined from the wet end. These same samples give the best resolution. Hydrolysis of amorphous material is the usual means of sharpening cellulose x-ray diffraction peaks, so that the very good resolution found may be connected with the presence of only small amounts of amorphous material in the fibers at that stage of aging.

Table V. Aging of Spruce Sulfite Pulp

Determination	*Nonmercerized*	*Time of aging, min.* 0	90	120	150	180	210	240	270	300	420
D.P.	1041	864	672	591	534	495	472	453	446	433	385
Desorption, %	...	7.95	7.83	8.35	8.06	8.68	9.75	9.03	8.44	8.32	8.76
Regain, %	4.25	7.04	6.86	7.61	7.80	7.43	7.04	8.16	7.66	7.33	7.18
Sedimentation volume, wet, ml.	...	330	360	260	320	340	360	320	310	310	280
Solvent water, mol./C_6	2.03	1.86	2.08	2.36	3.12	1.71	1.04	1.37	2.08	1.90	1.36
H-bonded water, mol./C_6	0.78	1.14	1.26	1.04	1.02	1.04	1.18	1.02	0.92	1.02	1.03
Drying rate at 20% moisture $\times 100$	4.04	3.71	3.41	3.36	2.99	4.02	4.73	4.41	3.86	3.83	4.41
Second rate slope $\times 100$	1.96	2.60	2.51	2.46	2.40	2.31	1.96	2.22	2.45	2.45	2.36
Diffraction peaks at $^1/_2$ max., $2\theta°$											
(002) plane	2.00	...	1.95	...	...	1.78	1.72	...	1.79	..	...
($10\bar{1}$) plane	...	...	1.63	...	...	1.62	1.48	...	1.64	...	...
Resolution	v. g.	...	g.	...	...	v. g.	v. g.	...	g.	..	...

Table VI. Aging of Prehydrolyzed Sulfate Pulp from Southern Mixed Hardwoods

Determination	*Nonmercerized*	*Time of aging, min.* 30	60	120	150	180	210	270	300	360
D.P.	965	705	625	532	486	454	418	372	350	324
Desorption	...	9.87	8.92	9.11	9.38	9.49	9.15	9.18	9.42	9.73
Regain, %	4.04	6.18	6.15	...	6.26	6.01	6.28	5.84	5.82	6.72
Sedimentation volume, wet, ml.	...	215	170	220	230	240	215	180	180	200
Solution water, mol./C_6	1.79	3.56	3.38	3.16	2.96	2.43	2.78	2.94	2.59	1.64
H-bonded water, mol./C_6	0.72	1.32	1.25	1.12	1.16	1.28	1.18	1.02	0.98	0.83
Drying rate at 20% moisture $\times 100$	4.36	3.31	3.28	3.54	3.64	3.88	3.63	2.69	3.73	4.29
Second rate slope $\times 100$	2.35	1.72	1.83	1.70	1.66	1.57	1.73	1.93	1.86	2.28
Diffraction peaks at $^1/_2$ max., $2\theta°$										
(002) plane	1.76	...	2.00	...	...	1.88	...	...	2.15	...
($10\bar{1}$) plane	...	...	1.85	...	...	1.61	...	...	1.69	...
Resolution	v. g.	...	g.	...	...	v. g.	...	...	g.	...

Table VII. Aging of Prehydrolyzed Sulfate Pulp

Determination	*Nonmercerized*	*Time of aging, min.* 30	60	90	120	150	180	210	240
D.P.	615	572	530	493	460	436	419	408	398
Desorption, %	...	8.62	8.15	8.23	9.11	8.87	8.65	8.94	9.13
Regain, %	4.04	6.33	6.35	6.22	6.05	6.23	5.75	5.90	6.13
Sedimentation volume, wet, ml.	...	260	245	215	280	250	240	240	250
Solvent water, mol./C_6	1.62	3.42	3.21	2.87	2.27	2.67	2.87	2.28	1.79
H-bonded water, mol./C_6	0.70	1.16	1.04	1.08	1.24	1.11	1.02	0.92	0.88
Drying rate at 20% moisture $\times 100$	4.51	2.93	3.05	3.31	3.62	3.42	3.30	3.75	4.23
Second rate slope $\times 100$	2.19	2.12	2.24	2.16	2.04	2.11	2.16	2.20	2.32
Diffraction peaks at $^1/_2$ max., $2\theta°$									
(002) plane	1.76	...	...	...	1.31	...	1.54	...	...
($10\bar{1}$) plane	...	...	...	...	1.61	...	1.68	..	..
Resolution	v. g.	...	...	...	v. g.	...	g.	...	..

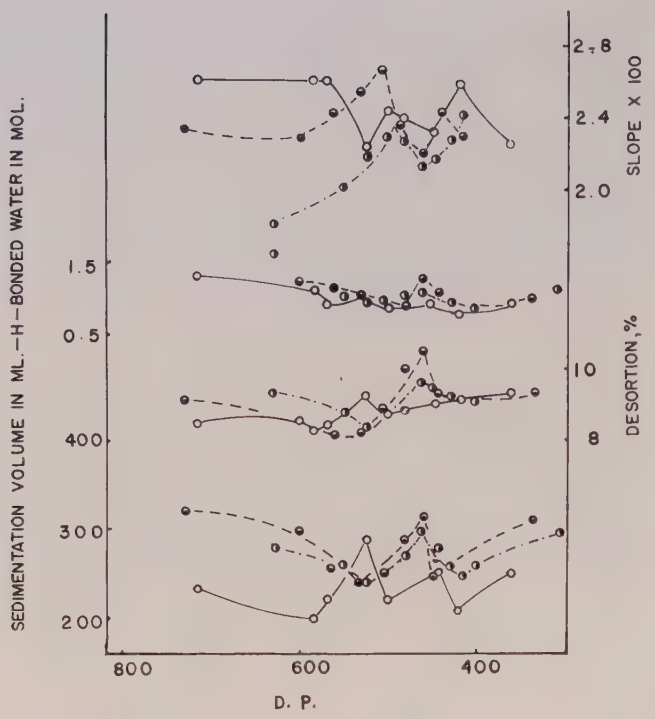

Fig. 1. Changes in the system fiber–eater with changes in D.P. during aging of alkali celluloses

Slope = second rate slope of drying curve. ○—— ——○. cotton linters pulp ◑——·——◑ prehydrolyzed sulfate pine pulp ◒– – –◒sulfite pine pulp.

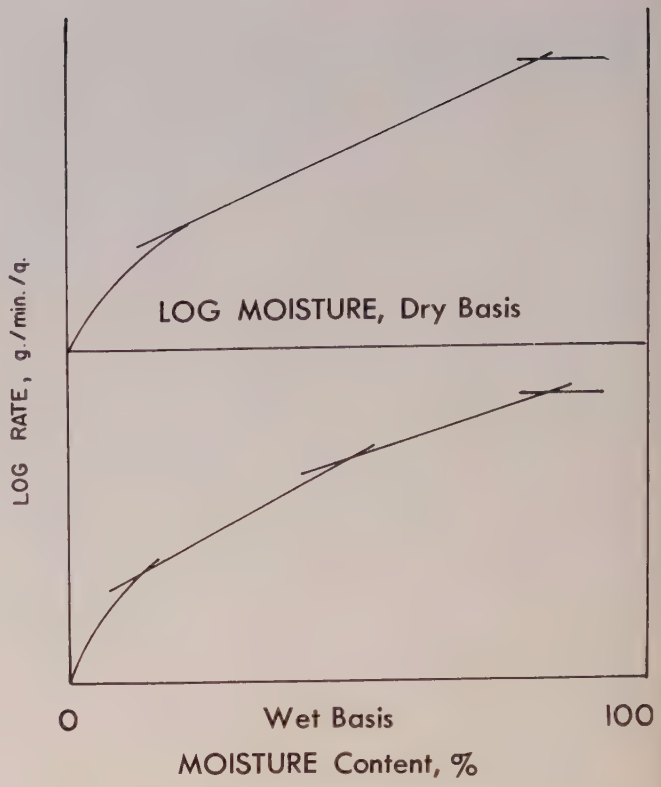

Fig. 2. General form of log rate of drying vs. moisture content on wet basis and vs. log moisture content on dry basis curves

From x-ray diffraction we can therefore deduce that during aging structural changes occur which result in changes in the size or in the arrangement of ordered regions. As the x-ray diffraction was determined on dried fibers, it is not possible to make deductions about the structure of the wet samples.

Regain measurements on completely dried samples show that a minimum of regain is characteristic for the samples which showed a maximum on desorption. The sedimentation volume of the immersed dry fibers also shows a minimum for these samples.

These determinations of x-ray diffraction, the regain and the sedimentation volume of the dried fibers which show the highest swelling, if investigated from the wet end, it is evident that every indication is present of "recrystallization" during drying (*7*).

CONCLUSIONS

Studying the system fiber–water from the wet end of the fibers regenerated from alkali celluloses at various stages of aging, a point of maximal swelling is observed at definite ranges of the D.P. The total uptake of water is accompanied by the greatest amount of hydrogen-bonded water and the least resistance against diffusion of water from the interior to the surface of vaporization of the fibers. The open structure of the fiber is also indicated by the lowest amount of solution water found at this stage.

The question, left open by determinations from the wet end, whether this is caused by the thorough opening up of crystalline regions or by the presence of large disordered regions could be answered by measurements on these fibers after drying. X-ray diffraction measurements indicate that the ordered regions of dried fibers, which showed maximal swelling in the wet state, are the largest in size. From the very good resolution of the peaks the presence of only small amounts of amorphous material has to be deduced. The same fibers exhibit, in this stage, a minimum of total swelling, as expressed by the sedimentation volume and the regain. The organization of the ordered regions in the wet cellulose fibers must therefore be high, so that during drying large ordered regions are reformed. The high degree of swelling or opening up of the cellulose fibers during aging is therefore caused by thorough swelling of the ordered regions, permitting larger amounts of free water to penetrate into the fibers and facilitating diffusion, and not by a transformation of ordered regions into less ordered ones.

This explains the results of previous experiments (*1*), that from aged alkali celluloses, showing high sedimentation volumes, xanthates of higher gamma-values are obtained and that in those xanthates a more uniform distribution of xanthate groups is probable. At this stage of aging the diffusion of carbon bisulfide into the interior of the ordered regions will be enhanced.

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Determination of Carboxyl in Cellulose

Comparison of Various Methods TAPPI-ACS-ASTM-ICCA Subcommittee on Determination of Carboxyl

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Data on the carboxyl content of eight ICCA pulps were obtained by eight different methods from eight laboratories. Replication of some of these methods resulted in 15 sets of data. Data were obtained by (1) determining the acid liberated upon addition of de-ashed pulp to a salt solution by the methods of Ant-Wuorinen, Karin Wilson, Lüdtke, and exchange with sodium sulfate, and (2) determining the decrease in cation concentration of a salt solution by de-ashed pulp by the methods of Sobue and Okubo, Davidson, Doering, and Rebek.

A statistical analysis of the data showed that the major source of within-laboratory variability arises from differences in the manner in which different pulps respond to the method of analysis. Results obtained by different methods of analysis in the same laboratory are somewhat more variable than results obtained by the same method in different laboratories. The coefficient of variation varied from about 20% for pulps with about 0.5 millimole of carboxyl per 100 g. of pulp to about 5% for pulps containing about 5 millimoles of carboxyl. Replication within a laboratory does not materially improve the overall precision. One or two reference pulps would materially improve interlaboratory precision.

VARIOUS methods for the determination of carboxyl groups in cellulose have been used for many years, but no method has ever been suggested by any organization as a tentative standard. The work reported in this paper represents the first step in the selection of a standard method, namely, the collection of data from different laboratories using different methods on the same group of pulps.

A review of the literature and an analysis of the problems associated with the determination of carboxyl in cellulose are not given here, as several articles of this nature are already available: Davidson and Nevell (*1–6*); Jayme and Neuschäffer (*7*); Stübchen-Kirchner (*8*); and Millett, Schultz, and Saeman (*9*). Ant-Wuorinen (*10–13*), and Ant-Wuorinen and Visapää (*14–18*) have published a series of articles on the determination of carboxyl in cellulose.

MATERIALS

In 1957 the International Committee for Cellulose Analysis (ICCA) collected a group of pulps for use by various committees in interlaboratory testing (*19*). Some of these pulps are available from E. E. Hembree, The Buckeye Cellulose Corp., Memphis, Tenn., and the remainder are available from Miss Karin Wilson, Uddeholms Aktiebolag, Skoghallsverken, Skoghall, Sweden. Table I gives a brief description of these pulps along with data that have become available on their characterization (*20*). The ICCA pulps were used in the present interlaboratory comparison of several carboxyl methods.

Table I. Description of the ICCA Reference Pulps and Some Data on Their Characterization

Pulp no.	*Kind of pulp*	*Grade*	*D.P.*[a]	*Aldehyde,*[a] *millimoles per 100 g. pulp*	*Pentosans,*[b] *%*
1	Cotton linters	Acetate	1720	0.50	0.4
2	Sulfite	Acetate	1310	0.67	1.1
3	Prehydrolyzed sulfate	Tire cord	820	0.72	0.9
4	Sulfite	Rayon	940	1.24	2.0
5	Sulfite	Cellophane	660	1.09	1.3
6	Sulfite, birch	Rayon	820	1.67	4.7
7	Sulfite	Paper	1250	1.24	4.2
8	Sulfite	Greaseproof	1240	2.75	5.2
9	Sulfite, birch	Rayon	...	...	4.0

[a] From Morrow's data, reference (*20*).
[b] Data by Orcinol Method from ACS-ASTM-TAPPI-ICCA interlaboratory testing program (*32*).

METHODS

The pulps were analyzed by the method normally used in each laboratory; some laboratories made analyses by more than one method (see Tables II and III). Literature references are cited to the methods that are well documented. Modifications of original methods and methods not described in the literature or not readily available are given in the Appendix.

Method of Ant-Wuorinen and Visapää (16)

The acid is titrated following liberation by exchange with a salt solution. A unique feature of this method is that water saturated with carbon dioxide is used to de-ash the cellulose. These authors have developed an elaborate automatic titration outfit for the estimation of the small amounts of acid involved in carboxyl determinations.

Method of Sobue and Okubo (21)

The exchange capacity is determined by passing a dilute calcium acetate solution through a de-ashed pulp column and measuring the decrease in calcium concentration by titration with a standard solution of ethylenediaminetetraacetic acid (EDTA). Millett (*9*) modified this method by substituting rubber stoppers

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This work is the result of a cooperative effort of the following individuals and laboratories: Prof. Olli Ant-Wuorinen, State Institute for Technical Research, Helsinki, Finland; Dr. Merrill A. Millett, Forest Products Laboratory, Madison, Wis.; Dr. Mark Plunguian, Hercules Powder Co., Wilmington, Del.; Forrest Sutphin, West Virginia Pulp and Paper Co., Covington, Va.; Dr. Helmut Doering, Aschaffenburger Zellstoffwerke, Aschaffenburg, Germany; Miss Karin Wilson, Uddeholms Aktiebolag, Skoghallsverken, Skoghall, Sweden; Prof. M. Rebek, Technische Hochschule, Graz, Austria; William L. Morrow, National Bureau of Standards, Washington 25, D. C.

Table II. Carboxyl Data, in Millimoles of Carboxyl per 100 Grams of Ovendry Pulp, Obtained by Determining the Acid Liberated upon Addition of De-Ashed Pulp to a Salt Solution

Reported by:	*Ant-Wuorinen*			*Plunguian*			*Doering*	*Karin Wilson*			*Karin Wilson*			*Rebek*	
De-ashed with:	*CO_2*			*HCl*			*HCl*	*HCl*			*CO_2*			*Electrodialysis*	
Method:	*Ant-Wuorinen*			*Exchange with Na_2SO_4*			*Karin Wilson*	*Karin Wilson*			*Karin Wilson*			*Karin Wilson*	*Lüdtke*[a]
Code no. in Table IV:	*1*			*3*			*7c*	*7a*			*8*			*7b*	*10*
ICCA pulp no.			*Average*			*Average*	*Average*			*Average*			*Average*		
1	0.57	0.57		0.40											
	0.38	0.56		0.45											
	0.55	0.58	0.57	0.30	0.38		0.42	0.41			0.50			0.33	0.31
2	1.85	1.78		1.81											
	1.81	1.79	1.81	1.60											
	1.85	1.79		1.66	1.69		1.47	1.64			1.69			1.64	1.33
3	1.53	1.60		1.53											
	1.56	1.57	1.57	1.56											
	1.60	1.56			1.55		1.55	1.46			1.46			1.42	0.73
4	2.01	1.98		2.28											
	1.97	1.95	1.98	2.06											
	1.99	1.96		2.08	2.14		1.78	1.99			1.86			1.53	0.91
5	2.47	2.42		3.40											
	2.42	2.40	2.43	3.60											
	2.43	2.46		3.30	3.43		2.89	2.66			2.28			2.87	1.33
6	3.93	3.88		4.83											
	3.87	3.88	3.89	4.77											
	3.90	3.89			4.80		4.13	3.83			3.63			4.60	2.64
7	5.58	5.51		7.87		5.68									
	5.53	5.58	5.54	6.92		5.79		5.93			5.68				
	5.52	5.51			7.40	5.79	5.75	5.84	5.89		5.63	5.65		5.60	3.73
8	6.78	6.69		7.09		7.00		7.43			5.94				
	6.75	6.67	6.73	7.15		7.00		7.47			6.18				
	6.71	6.75			7.12	7.06	7.02	7.00	7.30		5.72	5.95		6.18	5.54
9								2.97			2.83				

[a] The amount of acetic acid liberated (Lüdtke) and the amount of calcium consumed (Sobue and Okubo) were determined on the same solution.

for ground glass joints and by reducing the size of the apparatus.

***Method of Doering* (22)**

The cellulose is de-ashed with hydrochloric acid and allowed to react with zinc acetate solution. The amount of zinc bound by the carboxyl groups is determined by titration of the zinc acetate solution, before and after reaction with the cellulose, with EDTA.

***Method of Karin Wilson* (23)**

The acid is liberated from a pulp specimen, previously de-ashed with hydrochloric acid, by a solution of sodium chloride and sodium bicarbonate and the

Table III. Carboxyl Data, in Millimoles of Carboxyl per 100 g. of Ovendry Pulp, Obtained by Determining the Decrease in Cation Concentration of a Salt Solution by De-Ashed Pulp

Reported by:	*Millett*			*W. L. Morrow*		*Sutphin*	*Doering*	*Karin Wilson*			*Rebek*		
De-ashed with:	*HCl*			*Not de-ashed*		*Not de-ashed*	*HCl*	*HCl*			*Electrodialysis*		
Method:	*Sobue and Okubo*			*Davidson*		*Davidson*	*Doering*	*Doering*			*Rebek*	*Sobue and Okubo*[a]	*Doering*
Code no. in Table IV:	*2a*			*4a*		*4b*	*6a*	*6c*			*9*	*2b*	*6b*
ICCA pulp no.			*Average*			*Average*	*Average*			*Average*			
1	0.50	0.50		0.50									
	0.50	0.56	0.52	0.50	0.50	0.56	0.36			...	0.80	0.29	0.36
	0.50	0.58		0.50									
2	1.78	1.84		1.62									
				1.58									
	1.82	1.88	1.82	1.61	1.62	1.82	1.47			1.65	1.36	1.31	1.42
	1.76	1.84		1.65									
3	1.56	1.60		1.46									
	1.54	1.58	1.56	1.48	1.48	1.65	1.47			1.17	1.22	1.24	1.20
				1.46									
	1.54	1.54		1.51									
4	2.10	2.04		2.05									
	2.02	2.12	2.07	2.08	2.04	2.04	1.80			1.33	1.60	1.71	1.78
	2.05	2.08		2.00									
5	2.98	2.72		3.03									
	2.58	2.58	2.67	2.94	2.94	3.11	2.93			2.37	1.98	2.62	2.44
	2.64	2.52		2.86									
6	...			4.59									
	...		4.40	4.39	4.42	4.54	4.05			3.61	3.82	3.67	3.58
	...			4.27									
7	...			5.38			6.32						
	6.36		6.27	5.32	5.53	5.88	6.43	6.36		5.03	5.09	4.71	5.09	5.54
	6.18			5.88			6.32			5.14				
8	...			7.04			7.49			6.90				
	7.56		7.52	6.94	7.26	6.75	7.60	7.53		6.62	6.76	6.29	6.18	6.58
	7.48			7.81			7.49			6.76				
9	3.36													
	3.44		3.48											
	3.64													

[a] Pulps shaken with 0.01 *M* calcium acetate solution, and not by the dynamic method of Sobue and Okubo. The determination of the liberated acetic acid (Lüdtke) and the consumption of calcium (Sobue and Okubo) were made on the same solutions.

Table IV. Carboxyl in Pulp—Summary of Analyses[a]

Code no. for set	Method	Laboratory	μ	All data included		Set no. 10 omitted		Sets 9 & 10 omitted	
				β	$V(\eta)$	β	$V(\eta)$	β	$V(\eta)$
1	Ant-Wuorinen	Ant-Wuorinen	2.64	0.929	13.1	0.923	17.2	0.914	19.3
2a	Sobue and Okubo	Millett	2.82	1.021	6.8	1.015	9.9	1.006	12.6
2b	Sobue and Okubo	Rebek	2.32	1.001	13.2	0.995	8.1	0.984	5.8
3	Exchange with Na_2SO_4	Plunguian	2.91	1.080	53.3	1.076	41.8	1.067	34.5
4a	Davidson	W. L. Morrow	2.73	1.001	13.5	0.996	11.5	0.986	12.6
4b	Davidson	Sutphin	2.83	0.960	13.9	0.956	10.4	0.948	8.4
6a	Doering	Doering	2.66	1.088	13.7	1.083	10.6	1.073	9.5
6b	Doering	Rebek	2.38	1.020	8.7	1.014	8.9	1.003	9.8
6c	Doering	Karin Wilson	2.26	1.065	45.6	1.057	52.1	1.045	49.2
7a	Karin Wilson	Karin Wilson	2.63	1.023	10.7	1.017	11.3	1.008	11.1
7b	Karin Wilson	Rebek	2.52	1.070	91.0	1.065	73.8	1.054	65.1
7c	Karin Wilson	Doering	2.62	1.023	13.6	1.018	10.1	1.008	9.3
8	Karin Wilson (de-ashed with CO_2)	Karin Wilson	2.48	0.918	25.0	0.913	27.0	0.904	27.3
9	Rebek	Rebek	2.34	0.878	102.6	0.872	111.6		
10	Lüdtke	Rebek	1.71	0.922	165.8				

[a] The values of μ are expressed in the original scale, for an easier evaluation of laboratory biases. The values of β do not depend materially on the scale. These values, as well as those of $V(\eta)$ are given in the transformed scale.

solution is titrated to a methyl red end point with 0.01 *N* HCl. The procedure is described in the Appendix.

Method of Davidson

Here an ion exchange occurs between the carboxyls of the cellulose and a buffered solution of methylene blue. De-ashing is unnecessary. A procedure based on Davidson's work (*2*), developed at the National Bureau of Standards for use with very small samples (unpublished work), was used in this interlaboratory study and is described in the Appendix.

Method of Exchange with Sodium Sulfate

The de-ashed specimen is soaked in sodium sulfate solution, standard sodium hydroxide is added in slight excess, and this excess titrated with standard hydrochloric acid. The procedure is described in the Appendix.

Method of Rebek (24–27)

The de-ashed specimen is treated with a solution of crystal violet base in benzene. The dye is then removed from the cellulose with acid and determined colorimetrically.

Method of Lüdtke (28)

The de-ashed cellulose is soaked in a dilute solution of calcium acetate and the acid that is liberated is titrated with standard alkali.

The methods fall into two general classes: (1) those in which the de-ashed pulp is added to an inorganic salt solution and the resulting mineral acid titrated with a standard base, and (2) those in which the de-ashed pulp is added to a salt solution and the decrease in cation concentration of the salt solution is taken as a measure of carboxyl content. Basic dyes are included in the second class. The methods of Ant-Wuorinen, Plunguian, Karin Wilson, and Lüdtke fall into the first class, and the methods of Sobue and Okubo, Davidson, Doering, and Rebek fall into the second class. It should be noted that Davidson's method does not appear to require de-ashed pulp (*5*, *29*).

RESULTS AND STATISTICAL ANALYSIS

Tables II & III give carboxyl data from eight laboratories on the ICCA pulps. The pulp samples were not randomized. It was requested that each individual carboxyl value be reported.

Prior to analysis, the data were transformed into a scale of a logarithmic type (*30*, *31*) to obtain an approximately constant variance of replication error for all pulps. All further analyses of the data were carried out in the transformed scale. In a preliminary statistical analysis of the interlaboratory data, all methods and participating laboratories were included. This analysis encompassed 15 sets of data, representing eight methods, with replications of four of the methods among some of the laboratories. The analysis showed rather large variability among methods and laboratories. It also pointed to two sets of data that showed appreciably more scatter than the remaining 13 sets.

Table IV contains a summary of these findings. Each set of data (method and laboratory) is characterized by three parameters, μ, β, and $V(\eta)$ (*30*, *31*). The meaning of these quantities is apparent from Fig. 1.

Consider a particular set, and plot the values obtained in this set for each material versus the average value for this material for all sets combined. A straight

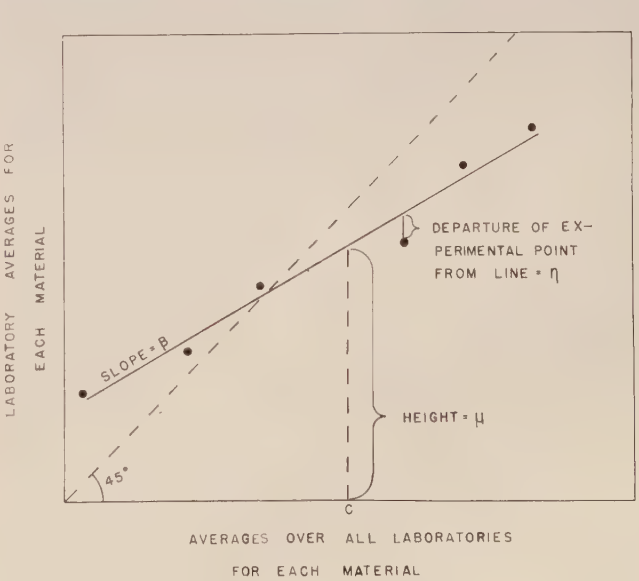
LABORATORY AVERAGES FOR EACH MATERIAL
DEPARTURE OF EXPERIMENTAL POINT FROM LINE = η
SLOPE = β
HEIGHT = μ
45°
C
AVERAGES OVER ALL LABORATORIES FOR EACH MATERIAL

Fig. 1. Linear model

C = average of all materials and all laboratories. η may be divided into two parts: that which can be accounted for by replication error (ϵ) and that due to the differential response of that laboratory to that material (λ).

Table V. Analysis of Variance[a]

Source of variation	Degrees of freedom	Mean square[b]
Sets (μ-values)	12	206
Between methods	6	218
Within methods	6	192
Materials	7	34,887
Interaction (sets × materials)	84	25.8
Eta	72	21.1
Slopes	12	54.1
Between methods	6	92.9
Within methods	6	15.3
Replicates	...	3.35

[a] Omitting sets 9 and 10 (see Table IV).
[b] Based on a transformed scale.

Table VI. Coefficient of Variation for Replication, Within-laboratory and Between-laboratory Errors

Carboxyl in sample, millimoles per 100 g. ovendry pulp	Coefficient of variation		
	Replication, %	Within-laboratories, %	Between-laboratories,[a] %
0.40	8.1	21	33
0.85	4.7	12	18
1.50	3.5	9.2	13
2.75	2.7	7.1	10
4.00	2.4	6.3	9.3
5.75	2.2	5.8	9.0

[a] Including differences arising from the use of the different methods examined in this study.

line is fitted to the points thus obtained. This line is the "response line" for the corresponding set. The parameter μ is the height of this line in its center. The parameter β is the slope of the line and $V(\eta)$ is the variance representing the scatter of the experimental points about this line. Table IV shows that sets 9 and 10, particularly the latter, show excessive scatter. After elimination of set 10 only, the relative scatter of set 9 is somewhat accentuated. Moreover, its values for both μ and β are abnormally low. It seems advisable, therefore, to re-examine the data after elimination of both sets, 9 and 10, to evaluate the degree of agreement that is realized among the 13 remaining sets, representing laboratories in five countries using seven different methods.

There is not sufficient evidence to detect differences in precision, if any exist, among the seven methods. On the other hand, there are interesting differences among the methods, as can be inferred from an analysis of variance of the data. Table V summarizes the findings of the analysis of variance. As stated earlier, the data were transformed into a different scale prior to analysis, in order to obtain an approximate equalization of the variance among replicate measurements for all samples. Furthermore, pulp no. 9 was not included in the analysis because of insufficient data.

In order to interpret the analysis of variance, compare first the two portions of the interaction mean-square. The quantity, referred to as "Eta," is a measure of the scatter of the experimental points about their corresponding lines. The mean-square labeled "slopes" measures the variability among the slopes of these various lines. It is seen that there is significant variability among these slopes. Furthermore, a further breakdown of the mean-square for "slopes" into two parts, corresponding respectively to sets of the same method of analysis (within methods) and sets for different methods of analysis (between methods), shows that the variability among the slopes is due entirely to differences between methods; different sets run according to the same method, though in different laboratories, showed no significant differences in slope.

So far, the discussion has been about the slopes of the response lines. One must also consider possible shifts of the lines upward or downward. Such shifts are measured by the mean-square labeled "Sets," which is related to the variance of the central points, μ, of the response lines. Here again, a breakdown is made into "within methods" and "between methods." But, contrary to what was found for the slopes, the variability in location of the lines, i.e., in the μ-values, is not significantly larger between methods than it is within methods.

Another interesting comparison is that of the mean-square for Eta with the mean-square for "Replicates." The latter was computed from the combined evidence provided by those laboratories that made two or more measurements on the same material. It is evident that the scatter of the data about the response lines cannot be accounted for by the variability among replicates. Thus, the agreement among replicates cannot, in this instance, be considered as a realistic measure of the reliability of the results.

Table VI lists the coefficient of variation for various levels of carboxyl-content and for three situations: (1) as based on the variability among replicates run on a given material in the same laboratory; (2) within a laboratory, for purposes of comparing different materials (see references *30*, *31*); and (3) between laboratories. The first of these three measures is computed from the variability among replicate measurements by the same laboratory, using a given method, on a given material. The second measures includes, in addition to this variability, also the random materials times laboratories interaction (denoted as $V(\lambda)$ in references *30* and *31*). Finally, the last measure includes in addition to these sources of variability, also the variability among laboratories.

CONCLUSIONS

1. Within-laboratory variability, for a given method of analysis, is not materially improved through replication of determinations on the same material. The major source of within-laboratory variability arises from differences in the manner in which different materials respond to the method of analysis.

2. For a given method of analysis, there exist systematic differences between the results obtained by different laboratories. However, a substantial part of these differences could be eliminated if each laboratory adjusted its results on the basis of a single reference material, by correcting each analysis by an amount equal to the difference between its value for the reference material and the assigned value.

3. Results obtained by different methods of analysis, even in the same laboratory, are somewhat more variable than those obtained by the same method in different laboratories. If no further development work can be done to bring the various methods into better agreement, the use of two reference materials may reduce somewhat the discrepancies between methods. One of the reference materials should have a carboxyl value at the lower end of the range, and the

other at the higher end. However, the benefit derived from the use of two reference materials will not be great.

4. Under present conditions, the determination of carboxyl by the methods included in this study is subject to a coefficient of variation of error of about 20% for materials with about 0.5 millimoles of carboxyl per 100 g. of pulp (see Table VI; coefficient of variation within laboratories). As the carboxyl content increases, the coefficient of variation decreases and reaches a value of about 5% for materials containing around 5 millimoles of carboxyl per 100 g. of pulp.

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APPENDIX

METHOD OF KARIN WILSON

A 2.5 g. specimen is disintegrated in distilled water, drained off on a fritted glass filter and slurried to about 1% concentration in 0.1 *N* HCl at room temperature. After 2 hr. the specimen is collected on a fritted glass filter funnel and washed with distilled water saturated with carbon dioxide. The washing must be continued until the filtrate, after boiling, does not consume more than 1 to 2 drops of 0.01 *N* NaOH to change the methyl red color. The wet pulp pad is weighed and placed in a 250-ml. Erlenmeyer flask fitted with a ground glass stopper. Fifty milliliters of a solution 0.1 *N* in sodium chloride and 0.01 *N* in sodium bicarbonate are added, and the flask is shaken to obtain a homogeneous slurry. After 1 hr. the specimen is filtered through a thoroughly cleaned and dried fritted glass filter funnel, and 25.00 ml. of the filtrate are titrated with 0.01 *N* HCl using methyl red as an indicator. When the first change in color occurs, the solution is boiled to expel the carbon dioxide, and the titration is then continued to a sharp color change. A blank is determined by titrating 25 ml. of the sodium chloride–sodium bicarbonate solution in the same way as the sample.

Calculation

The cation exchange capacity X_{Cation} of the pulp in milliequivalents per 100 g. is given by:

$$X_{\text{Cation}} = \left(b - a - \frac{av}{50}\right)\frac{2}{G}$$

where

G = weight of ovendry sample, g.
v = weight of water in the wet pulp pad, g.
a = volume 0.01 *N* HCl consumed by 25 ml. of sample solution, ml.
b = volume 0.01 *N* HCl consumed by 25 ml. of the sodium chloride–sodium bicarbonate solution, ml.

If the cation exchange capacity is very low, it is advisable to use a solution less than 0.01 *N* in $NaHCO_3$. The important point is that the excess of sodium bicarbonate should be large enough that the pH does not fall below 7.0.

METHOD OF DAVIDSON

Reagents

Methylene blue chloride, stock solution, 2.0 millimolar: Dissolve 0.640 g. of methylene blue chloride, making allowance for moisture, in water and dilute to one liter with water in a volumetric flask.

Buffer, stock solution: Dissolve 1.150 g. (6.25 millimoles) of veronal (diethyl barbituric acid) in water, add 4.0 millimoles of sodium hydroxide (using standard solution and buret), and dilute with water to 1 liter in a volumetric flask.

Methylene blue chloride-buffer solutions, freshly prepared, for carboxyl determination: Pipet 100 ml. of each of the above solutions into a 1-liter volumetric flask and dilute to the mark with water. The volume of solution to be prepared will vary with the requirements. If the procedure for small samples is followed, one might add 10 ml. of each of the stock solutions to a 100-ml. volumetric flask and dilute to the mark with water.

Procedure for Ordinary Size Samples

The approximate carboxyl content is first determined in a preliminary experiment. Three specimens are then weighed out, one estimated to give 50% exhaustion of the dye solution, one 10 to 15% smaller and one 10 to 15% larger, making allowance for the moisture content. The specimens are weighed into 125-ml. glass stoppered flasks (any other convenient size flask may be used) and 50 ml. of 0.2 millimolar methylene blue chloride-buffer solution is added from a pipet. The stoppers are lubricated with a little petroleum jelly and secured with rubber bands. The flasks are placed on a device that will turn them end-over-end or otherwise agitate the solutions.

After overnight agitation the solutions are centrifuged

and a 10-ml aliquot of the supernatant liquid pipeted into a 100-ml. volumetric flask. Ten ml. of 0.1 *N* HCl are added, and the flask is filled to the mark with water. The transmittancies of the solutions are measured at 6750 A.

The specimen size is plotted against the concentration of methylene blue chloride in the supernatant liquid, and the specimen size that gives 50% exhaustion of the dye solution is read from the plot.

The size specimen that gives 50% exhaustion of 50 ml. of 0.2 millimolar methylene blue chloride solutions has used 0.005 millimole of methylene blue chloride in ion exchange with carboxyl groups. Therefore:

$$\text{Millimoles of carboxyl per 100 g. of cellulose} = \frac{0.005 \times 100}{\text{grams of specimen to give 50\% exhaustion}}$$

In order to prepare a calibration curve, make up a series of methylene blue buffer solutions containing the same amount of buffer but different amounts of methylene blue, to cover the desired range. Add 50 ml. of the buffer stock solution to each of nine 500-ml. volumetric flasks. Add to these flasks 10, 15, 20, 25, 30, 35, 40, 45, and 50 ml., respectively, of the 2.0 millimolar stock solution of methylene blue chloride. Dilute each solution to the mark with water and mix thoroughly.

Pipet 10 ml. of each solution into a 100-ml. volumetric flask, add 10 ml. of 0.1 *N* HCl, dilute to the mark with water, and mix. Measure the optical density of the solutions and prepare a plot of optical density of 6750 A against concentration.

Procedure for Small Samples

The general procedure is the same as for ordinary size samples. Weigh the specimens into glass-stoppered weighing bottles of about 10-ml. capacity and add 5 ml. of 0.2 millimolar methylene blue chloride buffer solution. After overnight agitation the solutions are centrifuged, and a 1-ml. aliquot is removed with an automatic pipet and transfered to a 25-ml. volumetric flask. About $2^1/_2$ ml. of 0.1 *N* HCl is added, the solution diluted to the mark, and the transmittancy measured at 6750 A. The sample size that gives 50% exhaustion of the methylene blue chloride solution is determined as described above.

The size specimen that gives 50% exhaustion of 5 ml. of 0.2 millimolar methylene blue chloride solution has used 0.0005 millimole of methylene blue chloride in ion exchange with carboxyl groups. Therefore:

$$\text{Millimoles of carboxyl per 100 g. of cellulose} = \frac{0.0005 \times 100}{\text{grams of specimen to give 50\% exhaustion}}$$

In order to prepare a calibration curve, pipet 5 ml. of each solution into a 10-ml. glass-stoppered bottle and carry through the dilution procedure as in the determination of carboxyl using small specimens. Any specific procedure that gives solutions in the right concentration range should be satisfactory.

Blank

Pipet a blank (50 ml. or 5 ml.) from a 0.1 millimolar solution of methylene blue chloride plus buffer and carry it through the same dilution procedure as for the determination of carboxyl.

The tendency of methylene blue chloride solutions to form droplets on glassware can seriously impair the accuracy in transferring small volumes of solution. For this reason the 1-ml. automatic pipet should be coated with silicone to make it nonwettable. The pipet should be completely emptied during use, and should be calibrated in the same way in which it is used. An automatic pipet is highly desirable for the precise delivery of 1 ml. of solution.

METHOD OF EXCHANGE WITH SODIUM SULFATE

Principle

The sample is treated with dilute HCl to replace the alkali combined with the carboxyl group by a hydrogen ion. After washing to remove the excess acid, the addition of neutral sodium sulfate liberates acid by replacing the acid hydrogen of the carboxyl with sodium. An excess of standard NaOH is then added and the unreacted NaOH is titrated with standard HCl. The amount of carboxyl in the sample is calculated from the latter titration and reported as millimoles per 100 g. of cellulose.

The 0.01 *N* acid and alkali specified in this procedure are for pulps containing about 1 millimole of carboxyl per 100 g. of pulp. Stronger standard solutions should be used when more carboxyl is present.

Pulps containing 10 millimoles carboxyl, or more, per 100 g. of pulp are very difficult to wash acid-free. In such cases the wash water should be permitted to remain in contact with the pulp for 1 hr. or more.

Reagents and Apparatus

1. Standard hydrochloric acid, approximately 0.01 *N*.
2. Standard sodium hydroxide, approximately 0.01 *N*.
3. Hydrochloric acid, approximately 0.05 *N*. Dilute 4 ml. of 12 *N* HCl to 1 liter with water and mix well.
4. Sodium sulfate, 1 *M*, neutral. Dissolve 142 g. of anhydrous Na_2SO_4 in water and dilute to 1 liter. Adjust to pH 7.0 just before use.
5. Bromthymol blue indicator, 0.1% solution.
6. Bromcresol purple indicator, 0.1% solution.
7. Water, approximately pH 7.0. Make purple to bromcresol purple with 0.01 *N* NaOH.
8. Filter funnels, fritted glass of coarse porosity, 150-ml. capacity.
9. Blender-type stirrer.

Procedure

Disintegrate 10 to 15 g. of the sample in a blender. Weigh approximately 5 g. of this disintegrated sample into a 400-ml. beaker. Add 100 ml. of 0.05 *N* HCl, mix, and allow to stand for 30 min. Filter off the acid as completely as possible through a sintered glass funnel using maximum suction. Reduce the suction to a minimum and wash the mat eight times with 50-ml. portions of water. Drain the mat completely after each washing before adding another portion of wash water.

Return the mat to the beaker, add 100 ml. of 0.05 *N* HCl and allow to stand 30 min. Filter off the acid and wash as before with eight 50-ml portions of water. Return the mat to the beaker, add a third 100-ml.

portion of 0.05 N HCl, and allow to stand 30 min. Filter-off the acid, and place the mat in a liter beaker. Add 800 ml. of pH 7.0 water and allow to stand at least 15 min. Filter-off this water and return the mat to the 1-liter beaker. Add another 800-ml. portion of pH 7.0 water and continue washing in this manner until the wash water has a pH of 6.8 or greater (purple to bromcresol purple). Allow each portion of wash water to remain in contact with the sample at least 15 min.

Transfer the mat to a 500-ml. Erlenmeyer flask and add 100 ml. of 1 M Na_2SO_4 solution. Stopper and allow to stand for 30 min. Add 10 drops of bromthymol blue indicator and an excess (to blue color, normally 15 ml.) of 0.01 N NaOH. Shake well and titrate with standard 0.01 N HCl to the appearance of a green color.

Run a blank by adding to a 500-ml. Erlenmeyer flask, 100 ml. of 1 M Na_2SO_4 solution, 10 drops of bromthymol blue indicator, and the same amount of 0.01 N NaOH as was added to the sample, and titrate with standard 0.01 N HCl to the same green color as was used with the sample.

Determine per cent moisture in the original sample.

Calculation

The carboxyl content in millimoles per 100 g. is given by:

$$\frac{(B - A) \times N \times 100}{w}$$

where

A = volume of acid for sample, ml.
B = volume of acid for blank, ml.
N = normality of HCl
w = ovendry weight of specimen g.

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Growth and Respiration of a Green Alga in Spent Sulfite Liquor

THOMAS E. MALONEY and ERNEST L. ROBINSON

Experiments were carried out with a green alga, *Chlorococcum macrostigmatum*, in order to elucidate its metabolism in relations to (SSL) spent sulfite liquor and the reducing sugars present in SSL. The results indicate that the alga will grow well in low concentrations of SSL. However, SSL contains some component other than the reducing sugars which, when present in higher concentrations, inhibits both growth and respiration of the alga. In combination the reducing sugars, in the absence of the other SSL components, will support good growth both in the light and in the dark and are readily oxidized by the alga. Of the individual reducing sugars present in SSL the hexoses are more readily oxidized by the algae and support better growth in the light and in the dark than the pentoses.

In previous work (*1*) it was found that a green alga, *Chlorococcum macrostigmatum* Starr, would assimilate some of the sugars present in spent sulfite liquor (SSL). When growing in a basal medium of mineral salts containing 1.0% (0.57% solids and 0.13 g. per 100 ml. reducing sugars) of a softwood SSL concentrate, the alga utilized over 85% of the available reducing sugars in approximately 13 days of growth. In addition, a component of the SSL, probably the sugars, also served as an energy source for growth of the alga in the dark. Sugar utilization in the dark was comparable to that in the light. When the SSL concentration was increased the percentage of sugar utilized in the same length of time was progressively less.

The work described herein was carried out in order to elucidate the role of SSL and the reducing sugars present in SSL, in the metabolism of the alga. Experiments were conducted to determine the optimum SSL concentration for maximum algal growth and respiration and to determine the role of the reducing sugar components in this phase of the algal metabolism. It was also of interest to determine which of the sugars present in SSL were oxidized by the alga, what were the comparable rates of oxidation, and which of the sugars would permit growth of the alga in the light and also serve as an energy source for dark or heterotrophic growth. Studies were also made to determine if the sugars were oxidized more rapidly by the alga in the absence of the other SSL constituents.

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EXPERIMENTAL

Materials and Methods

The alga used in all of the experiments was *Chlorococcum macrostigmatum* Starr. The organism was maintained in a unialgal pure culture and its purity routinely tested by inoculation into bacteriological media and by microscopic examination. The basal culture medium on which it was grown was as follows: $Ca(NO_3)_2 \cdot 4H_2O$, 0.0232%; K_2HPO_4(anhydrous), 0.0010%; $MgSO_4 \cdot 7H_2O$, 0.0025%; $Na_2SiO_3 \cdot 5H_2O$, 0.0044%; Na_2CO_3(anhydrous), 0.0020%; ferric citrate, 0.00035%; and citric acid, 0.00035%.

All experiments were carried out with calcium-based SSL which resulted from the pulping of sprucewood. The liquor was supplied by the Sulphite Pulp Manufacturers' Research League, Appleton, Wis., and had been concentrated to 57% solids or approximately one fourth its original volume. The SSL concentrate contained 13.2 g. per 100 ml. reducing sugars (as glucose). Sugar determinations were made by the method of Dubey, *et al.* (*2*), which is a modification of the Somogyi method.

In all growth studies the culture medium was buffered to pH 8.0 with 0.1% tris(hydroxymethyl) amino-

methane and the temperature was maintained at 23°C. For growth in the light the flasks were placed under fluorescent lighting of approximately 200 ft.-c. intensity and for growth in the dark the flasks were wrapped in aluminum foil and placed under light-tight black cardboard boxes. When SSL was used it was sterilized by heating under pressure. Since the SSL

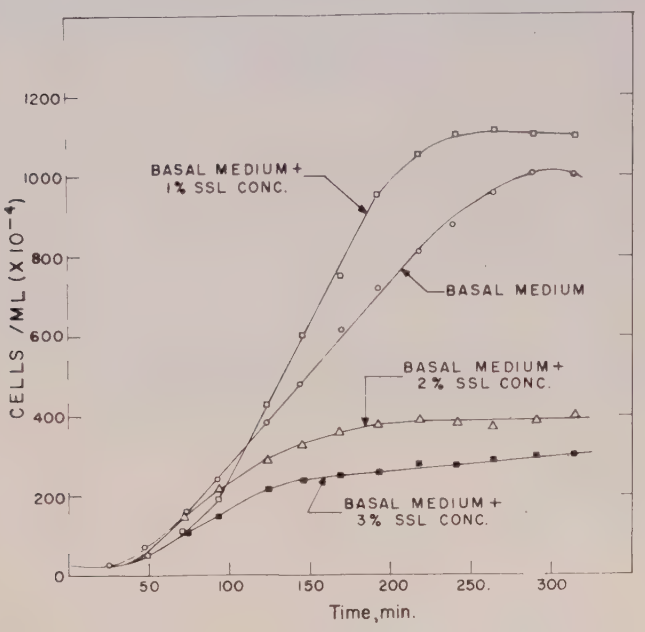

Fig. 1. Growth in basal medium and in basal medium supplemented with SSL concentrate

had already been subjected to heat treatment during concentration, it was assumed that this type of sterilization would not further degrade the sugars. The combination of sugars representing that in SSL was also sterilized in this manner in order to duplicate the treatment of the SSL. However, when the individual sugars were employed, they were sterilized by filtration and added separately to the sterile basal medium. Cell counts were made with a haemacytometer at a microscope magnification of 400×. All experiments were carried out in duplicate.

Growth Studies

Algal growth in the basal medium alone was compared with that in the basal medium supplemented with 1.0% (0.57% solids and 0.13 g. per 100 ml. reducing sugars), 2.0% (1.14% solids and 0.26 g. per 100 ml. reducing sugars), and 3.0% (1.71% solids and 0.40 g. per 100 ml. reducing sugars) of the SSL concentrate. In these studies Erlenmeyer flasks of 250-ml. capacity, containing 50 ml. of the growth medium with a 4.0% inoculum of an actively growing algal culture, were placed under continuous lighting.

Algal growth was also determined in the basal medium supplemented with 1.0, 2.0, and 3.0% of a sugar concentrate representing those sugars commonly found in softwood SSL (*3*). The sugar concentrate contained the following amounts of sugars dissolved in 100 ml. of distilled water: D-xylose, 1.12 g.; L-arabinose, 1.12 g.; D-mannose, 5.64 g.; D-fructose, 0.53 g.; D-glucose, 3.81 g.; D-galactose, 0.55 g.; and D-galacturonic acid, 0.42 g. This resulted in a sugar solution containing 13.2 g. per 100 ml. of reducing

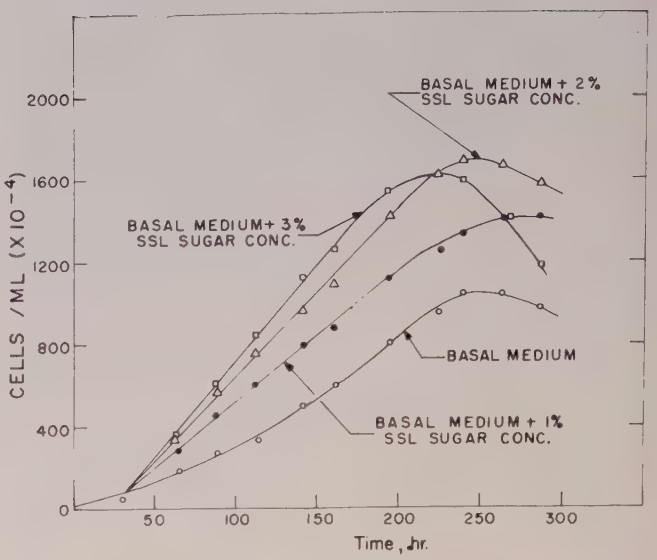

Fig. 2. Growth in basal medium and in basal medium supplemented with SSL sugar concentrate

sugars and identical with the SSL concentrate in total reducing sugar analysis.

In addition, each of the individual sugars present in SSL was tested separately to determine which would support growth of the alga in the light and would also serve as an energy source for growth in the dark. A 0.5% solution of D-mannose, D-fructose, D-glucose, D-galactose, D-galacturonic acid, D-xylose, and L-arabinose in 30 ml. of basal medium was placed in 125-ml. Erlenmeyer flasks with 3.3% algal inoculum. Cell counts were made at 67, 139, 211, 307, and 403 hr.

Respiration Studies

In all the respiration studies the direct manometric Warburg technique was employed (*4*) with air as the gas phase. Vessels of approximately 15-ml. capacity with sidearm and center well were used. All experiments were conducted at 30°C., and the water of the constant temperature bath was colored with a heavy solution of nigrosin, a black water-soluble dye, to prevent photosynthetic activity. A temperature equilibration period of 10 min. was allowed prior to closing the stopcocks, and the substrate was tipped from the sidearm after

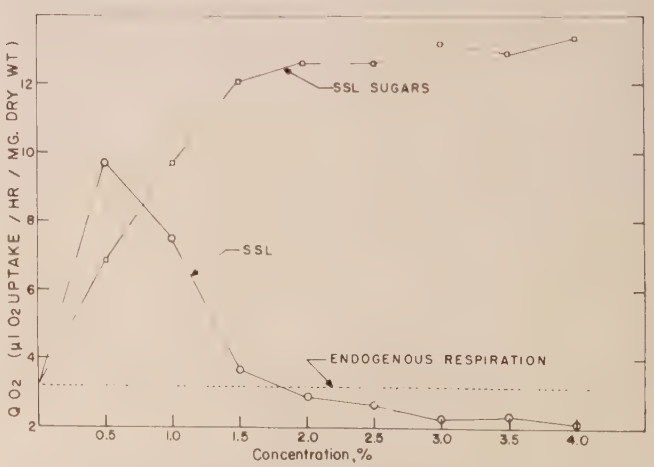

Fig. 3. Respiration rates in various concentrations of SSL and SSL sugars

Table I. Algal Growth[a] in the Light and in the Dark in Basal Media Containing Various Sugars[b]

Time, hr.	Control		L-Arabinose		D-Xylose		D-Glucose	
	Light	Dark	Light	Dark	Light	Dark	Light	Dark
0	240,000	240,000	240,000	240,000	240,000	240,000	240,000	240,000
67	2,410,000	180,000	2,230,000	200,000	270,000	170,000	3,710,000	300,000
139	5,630,000	60,000	5,780,000	110,000	230,000	160,000	9,780,000	1,480,000
211	8,050,000	60,000	10,660,000	80,000	90,000	100,000	10,450,000	3,690,000
307	11,160,000	60,000	11,710,000	80,000	90,000	90,000	9,640,000	5,470,000
403	12,850,000	60,000	9,260,000	80,000	110,000	40,000	7,020,000	6,080,000

Time, hr.	D-Mannose		D-Fructose		D-Galactose		D-Galacturonic acid	
	Light	Dark	Light	Dark	Light	Dark	Light	Dark
0	240,000	240,000	240,000	240,000	240,000	240,000	240,000	240,000
67	2,620,000	260,000	2,970,000	220,000	2,610,000	100,000	230,000	230,000
139	9,630,000	1,850,000	13,090,000	630,000	7,820,000	1,160,000	220,000	160,000
211	12,410,000	2,920,000	15,300,000	1,290,000	13,500,000	1,650,000	130,000	90,000
307	11,660,000	3,500,000	13,740,000	4,900,000	15,900,000	2,030,000	90,000	90,000
403	9,110,000	4,300,000	9,500,000	5,810,000	14,170,000	2,140,000	80,000	80,000

[a] Growth recorded in cells/ml.
[b] Sugars in 0.5% concentration.

endogenous respiration had attained a constant rate. The vessels were shaken at a rate of 110 complete 38-mm. strokes per min.

The algal cells used in these experiments were 7 to 10 days old and were cultured in basal medium under continuous lighting. The cells were harvested immediately prior to use and washed three times in distilled water. Dry weights were determined by drying aliquots of the cell suspensions 24 hr. at 105°C. in tared aluminum cups.

Experiments were conducted to determine the concentration of SSL at which the rate of algal respiration was at its maximum. The SSL concentrate (13.2 g. per 100 ml. reducing sugars) was tested in strengths of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, and 4.0%. The algal respiration rates in these SSL concentrations were compared with those in the same concentrations of sugar mixture containing the sugars ordinarily found in SSL. The sugar mixture was identical with that used for the growth experiments previously described. Each vessel contained 27.0 mg. dry wt. of algal cells, 0.1 *M* phosphate buffer (pH 4.5), 0.5 ml. of either SSL or sugar solution in sidearm (in six times the desired final concentration), 0.2 ml. of 20% KOH (in center well), and H_2O to give a volume of 3.0 ml.

The respiration rate of the alga was also determined in the presence of each of the individual sugars. The vessel contents were the same as above with the exception that 0.5 ml. of a 3.0% solution of each individual sugar was added from the sidearm. This gave a final concentration of 0.5% of a sugar in a vessel. Each vessel contained 15.6 mg. dry weight of algal cells.

RESULTS AND DISCUSSION

Figure 1 shows the growth curves of the alga in the light in the basal medium supplemented with 1.0, 2.0, and 3.0% of the SSL concentrate. Growth in the basal medium alone was slightly less than that in the basal medium supplemented with 1.0% of the SSL concentrate. However, when the SSL was increased to 2.0 and 3.0% of the concentrate, there was a decided decrease in algal growth indicating some growth-inhibiting substance present in the SSL, evidently not the reducing sugar component. When comparable concentrations of the reducing sugar component alone were present, there was no inhibition of growth (Fig. 2).

Although both D-xylose and D-galacturonic acid prevented growth of the alga in the light and in the dark when employed separately (Table I), their toxic nature was not evident when the other reducing sugars were present. The toxic nature of D-xylose is not surprising. Investigators (*5*, *6*) have found that xylose is not metabolized by other species of algae, and it has been reported (*7*) that xylose is a specific inhibitor of photosynthesis for *Chlorella pyrenoidosa*. The other pentose tested, L-arabinose, did not inhibit growth of the alga in the light, but neither did it serve as a chemosynthetic energy source for growth in the dark. While D-glucose, D-mannose, D-fructose, and D-galactose all served to allow some growth in the dark, in no case was growth in the dark as great as that in the light in the presence of these sugars. It appeared that, in some cases, growth in the light was stimulated by the addition of the carbohydrates. However, growth was measured in stationary flasks without the addition of carbon dioxide and it has been pointed out (*8*) that it is doubtful whether the addition of an organic carbon source will accelerate growth under conditions of light and carbon dioxide saturation.

The SSL was oxidized by the alga most rapidly at a 0.5% concentration (Fig. 3). At this SSL concentration the QO_2(μl. O_2 uptake per hr. per mg. dry wt.) was 9.7(endogenous respiration not subtracted). When 1.0 and 1.5% solutions of the SSL concentrate were tested, the QO_2's decreased respectively to 7.5 and 3.7. In 2.0% of the SSL concentrate, the QO_2 was less than that of endogenous respiration. This indicates that some component of the SSL was inhibiting respiration. However, as in the growth studies, it is evident that the inhibition was not caused by the sugars present in the SSL. In up to 1.5% of sugar concentrate alone the algal respiration rate increased rapidly; then, unlike the behavior in SSL the rate levelled off without further decrease.

There is also an indication that some SSL component other than the sugars will, in low concentration, stimulate respiration. In comparing the respiration rate in a 0.5% solution of the SSL concentrate with that in the same concentration of the sugars alone, the QO_2 in the SSL (9.7) is found greater than that (6.9) in the sugar solution. Nevertheless, the respiration rate rapidly declined in stronger SSL concentrations while it continued to increase in comparable concentrations of sugar.

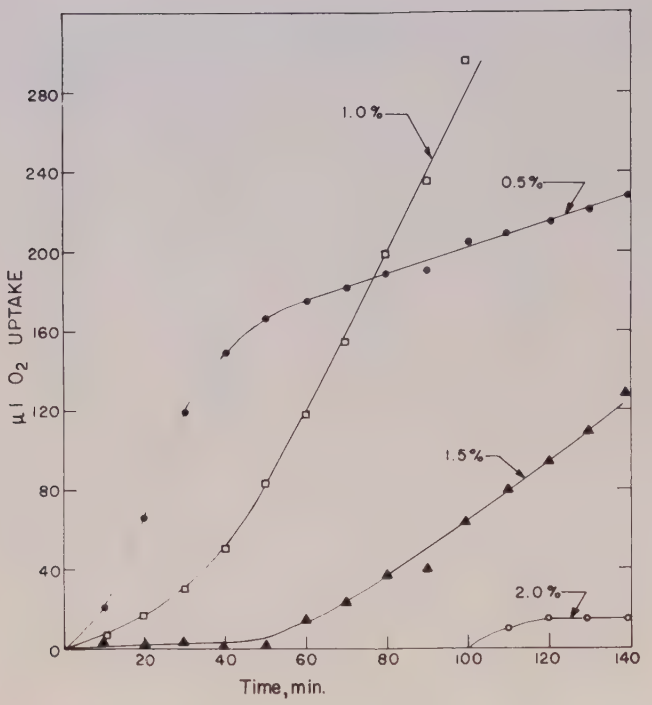

Fig. 4. Oxygen uptake in various dilutions f SSL concentrate

Endogenous respiration subtracted.

Figures 4 and 5 shows the oxygen uptake over a period of 140 min. in 0.5, 1.0, 1.5, and 2.0% solution of SSL concentrate, and in the same percentages of sugar concentrate, respectively. The initial oxygen uptake for the sugars alone was linear with time in all concentrations and then, beginning with lower concentrations, gradually levelled off. This decrease in oxygen uptake was probably due to the exhaustion of the sugars present. In SSL, however, there was a lag before the oxygen uptake became linear with time, and the lag became more pronounced as the SSL concentrations were increased. This again indicates the toxic nature of the SSL at higher concentrations. It also appears that the alga was able to adapt to the SSL to some extent and thus, after the initial lag in respiration, oxidized the sugars more rapidly.

Of the individual sugars present in SSL, only the three hexoses, D-glucose, D-mannose, and D-fructose, were readily oxidized by the alga (Fig. 6), whereas, D-galactose and D-galacturonic acid were oxidized to only a small degree. Although D-xylose was oxidized slightly, there did not appear to be any respiratory activity in the present of L-arabinose. The slight increase in respiratory activity when the L-arabinose was first added may have been due to contamination with another sugar.

SUMMARY AND CONCLUSIONS

Experiments were carried out with a green alga, *Chlorococcum macrostigmatum*, in order to elucidate its metabolism in relation to SSL and the reducing sugars present in SSL. The results indicate that the alga will grow well in low concentrations (0.57% solids) of SSL. However, SSL contains some component, other than the reducing sugars which, when present in higher concentrations inhibits both growth and respiration of the alga. In combination, the reducing sugars, in the absence of the other SSL components, will support good growth both in the light and in the dark and are oxidized readily by the alga. Of the individual reducing sugars present in SSL, D-glucose, D-mannose, D-galactose, and D-fructose will support algal growth both in the light and in the dark, whereas, L-arabinose will permit growth in the light only. Both D-xylose and D-galacturonic acid prevent growth in the light and in the dark.

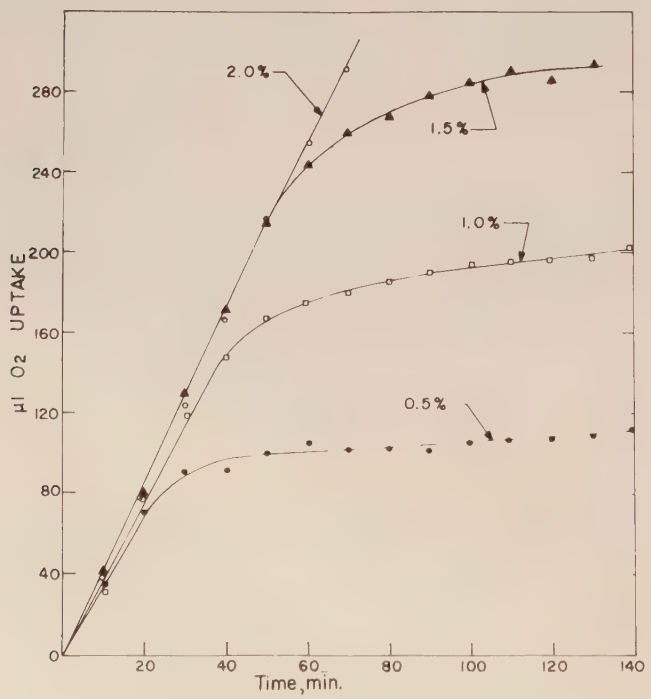

Fig. 5. Oxygen uptake in various dilutions of SSL sugars

Endogenous respiration subtracted.

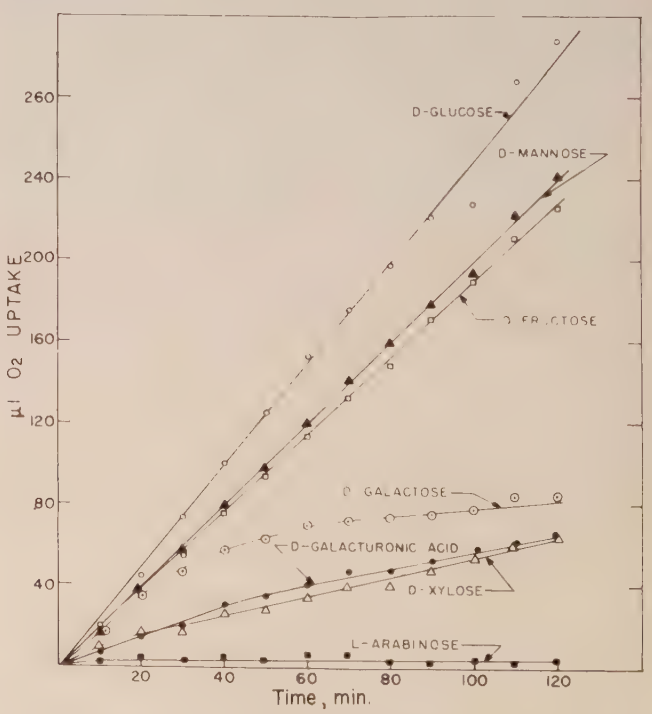

Fig. 6. Oxygen uptake in the presence of the individual SSL sugars

Endogenous respiration subtracted.

Three of the hexoses, D-glucose, D-mannose, and D-fructose, are rapidly oxidized by the alga, whereas D-galactose, L-arabinose, D-xylose, and D-galacturonic acid are oxidized to little or no extent.

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Variation of Some Wood and Pulp Properties in an Even-Aged Loblolly Pine Stand

J. P. VAN BUIJTENEN, BRUCE J. ZOBEL, and P. N. JORANSON

Twenty-four loblolly pines from a natural even-aged old field stand were sampled on the West Virginia Pulp and Paper Co. Experimental Forest near Georgetown, S. C. On the wood samples collected, a number of physical and chemical determinations were made at North Carolina State College and The Institute of Paper Chemistry, while in addition a small pulp sample was prepared at The Institute of Paper Chemistry. A combined analysis of the data obtained in both research programs showed a large tree-to-tree variation with respect to many properties which might be useful for genetic improvement. A consideration of the various relationships between wood and pulp properties brought to light that fiber length is the most important single factor related to pulp strength as measured by the zero-span tensile-strength test. Yield is significantly correlated with the per cent lignin, the per cent cellulose, and the per cent extractives. Since the per cent cellulose and the per cent lignin are fairly strongly correlated it is rather inefficient to carry out both analyses on the same samples as a measure of potential pulp yield, and a choice between the two methods should be made on the basis of the desired accuracy and cost considerations.

GENETIC improvement of trees mainly utilized for pulpwood should not primarily be aimed at an increased volume production but rather at the highest production per acre of the highest quality wood and cellulose. The development of suitable techniques for the determination of pulp yield and pulp quality from standing trees by nondestructive means is a prerequisite for the achievement of maximum improvement, although it is only one of many such prerequisites. Other important aspects of the same problem are concise definitions of good and poor quality, a study of the factors, both internally controlled and environmentally controlled, that influence quality, a study of the variation within and between species of the properties involved, and the economic importance of the characteristics under consideration.

The present paper describes the natural variation in a number of wood and pulp properties closely related to pulp yield and pulp quality, as well as the relationship between these properties, and the method used for their determination. This study was made possible through the cooperation between the forest genetics programs of North Carolina State College and The Institute of Paper Chemistry, each of which supplied a portion of the data obtained from the same trees.

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MATERIALS AND METHODS OF ANALYSIS

Twenty-four loblolly pines from a natural even-aged old field stand were sampled on the West Virginia Pulp and Paper Co.'s Experimental Forest near Georgetown, S. C. Wood samples were obtained to determine the variability of wood properties from tree to tree in a natural stand from unselected dominant and codominant individuals. The first collection was made in 1956, consisting of two, 10-mm. increment cores from opposite sides of the tree (Fig. 1). Only "nonpitchy" cores were used. In addition to measurements of growth rate and form, the specific gravity, the water-resistant carbohydrates, the alpha-cellulose content and the amount of compression wood were determined at N. C. State College. The determinations were made independently on core wood and outer wood. An empirical method of separation was used as described by Zobel, *et al.* (*1*).

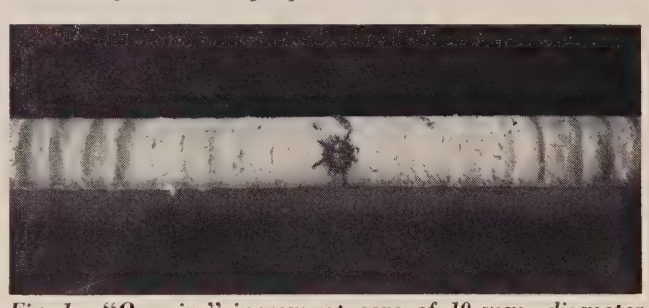

Fig. 1. "Oversize" increment core of 10-mm. diameter used to classify wood properties of trees under study
Note the dark area of pith at the center of the tree. Wood near the pith is often referred to as core wood.

Wood analysis was made by standard methods whenever feasible. Specific gravity was determined by the standard ovendry weight–green volume relationships on nonextracted cores. Water-resistant carbohydrates (WRC) and alpha-cellulose were obtained by a rapid micromethod reported by Zobel and McElwee (*2*).

Table I. Cooking Conditions

Maximum temperature, °C.	172
Time from 132 to 172°C., min.	60
Time at 172°C., min.	105
Liquor concn., g./l. as NaOH	40.2
Sulfidity, %	15.5

Per cent compression wood was estimated by means of the "light box," a method of visually estimating compression wood [Forest Products Lab. (*3*)].

A second collection from the same tree was made in 1958; at this time four 10-mm. increment cores were obtained at breast height located at 90° angles with each other. The material obtained in the second collection was analyzed at The Institute of Paper Chemistry and was used for the determination of the per cent summerwood, the per cent alcohol–benzene extractives, the per cent lignin, and the preparation of a small pulp sample.

On the intact cores the number of annual rings and the per cent summerwood was determined. The determination of per cent summerwood was carried out under a dissecting scope at a magnification of 10 times. The cores were then divided lengthwise into two parts, a 20% portion which was used for chemical analysis and the remaining 80% which was pulped.

The chemical analyses made included the per cent alcohol–benzene extractives and the per cent lignin and were carried out according to TAPPI Standard T 6 m-54 and T 13 m-54.

The pulping operation was carried out in a digester assembly containing seven individual digesters, which rotate in an electrically heated oil bath. The exact cooking conditions of the kraft process employed are given in Table I. More detailed descriptions of the apparatus and its operation are given by Thode (*4*) and van Buijtenen, *et al.* (*5*).

The determinations made on the pulp include fiber length, yield, and permanganate number. The fiber length was determined as the average of 300 measurements. The yield was obtained from the weight of the moist pulp, in the form of a pad made on a Buchner funnel, and its moisture determinations. The permanganate number was obtained following TAPPI Standard T 214 m-50.

From the pulp, handsheets were prepared on which zero-span tensile strength, basis weight, caliper, and apparent density were determined.

DISCUSSION AND SUMMARY OF RESULTS

A summary of the data is presented in Table II. In addition to the averages and the standard deviations, many of the possible correlation coefficients were calculated; only those which are of particular interest will be presented here.

The relationships between wood properties and pulp properties are of primary importance for forest tree improvement. One would like to know, for instance, which properties influence pulp yield. It has been well established that the yield per volume of wood is strongly dependent on the specific gravity of the wood. It is a point of interest whether this is also the case if the yield is expressed on a weight basis. Since specific gravity and per cent summerwood are normally strongly correlated, the relationship of yield to this factor should also be considered. One would further expect pulp yield to be strongly influenced by a number of chemical properties, such as the water-resistant carbohydrates, the per cent cellulose, the per cent extractives, and the per cent lignin. A summary of the correlation coefficients calculated between these variables is shown in Table III.

In this study, pulp yield is apparently related to specific gravity even when it is determined on a weight basis. It also shows a significant relation with water-resistant carbohydrates, alpha-cellulose content, per cent alcohol–benzene extractives, and per cent lignin. Since some of these variables are fairly well correlated

Table II. Wood and Pulp Properties

Tree no.	*Specific gravity*	*Summer-wood, %*	*WRC, %*	*Alpha-cellulose, %*	*Alcohol–benzene extractives, %*	*Lignin, %*	*Yield, %*	*Fiber length, mm.*	*Zero-Span tensile strength, lb./in.*	*Compression-wood, outer, %*
11-1-1	0.61	48	81.3	58.1	5.9	28.55	41.5	1.98	45.1	18
11-1-2	0.54	43	80.7	56.6	9.0	27.55	40.4	2.20	42.8	14
11-1-3	0.54	40	79.6	55.6	5.2	29.0	40.0	2.16	44.2	13
11-1-4	0.56	50	81.8	58.1	6.2	27.7	42.9	2.42	46.9	10
11-1-5	0.55	48	80.6	57.7	7.8	28.9	39.9	2.30	50.3	0
11-1-6	0.60	47	80.2	57.1	10.6	28.5	40.1	2.22	42.5	6
11-1-7	0.56	43	80.0	57.8	9.5	28.6	40.6	2.03	40.7	0
11-1-9	0.51	39	79.2	55.5	11.9	29.35	39.2	2.12	49.2	12
11-1-10	0.58	59	79.6	56.8	7.8	29.4	40.7	2.34	44.8	8
11-1-11	0.55	45	78.2	54.4	8.6	30.05	39.5	2.11	41.9	34
11-1-12	0.59	52	78.9	55.2	8.3	28.9	41.0	2.22	45.8	21
11-1-13	0.55	42	78.7	55.9	6.4	27.95	41.2	1.99	45.5	12
11-1-14	0.53	44	79.7	56.0	7.9	29.0	40.1	1.91	44.8	9
11-1-15	0 55	45	79.3	56.2	6.0	29.1	41.9	2.05	46.0	0
11-1-16	0.50	47	78.7	54.6	10.6	28.8	39.1	1.96	45.2	37
11-1-17	0.59	48	78.1	57.2	9.6	28.2	40.2	1.91	45.9	26
11-1-18	0.59	41	79.7	59.3	7.8	26.1	42.2	2.30	55.6	7
11-1-19	0.55	42	78.0	53.4	14.3	29.2	39.9	1.96	43.4	12
11-1-21	0.52	51	80.9	55.7	6.5	28.3	41.7	2.37	50.7	0
11-1-22	0.51	40	78.3	53.0	12.4	29.8	35.8	1.86	40.3	17
11-1-23	0.53	45	81.4	56.6	8.5	27.0	39.9	2.17	45.0	0
11-1-24	0.54	46	78.1	52.0	5.7	29.3	41.3	1.98	41.8	27
11-1-25	0.57	52	80.3	55.1	5.3	29.5	40.4	2.18	48.4	4
Average	0.553	46.0	79.6	56.0	8.33	28.6	40.4	2.11	45.5	12.5
Standard deviation	0.029	4.7	1.1	1.7	2.37	0.9	1.4	0.16	3.5	10.5

Table III. Correlation Coefficients Between a Number of Selected Variables

Variables		*Correlation coefficient*
Specific gravity	Summerwood, %	0.41
Specific gravity	WRC, %	0.17
Specific gravity	Alpha-cellulose, %	0.53
Specific gravity	Alcohol–benzene extractives, %	−0.25
Specific gravity	Lignin, %	−0.23
Specific gravity	Yield, %	0.48
Summerwood, %	WRC, %	0.27
Summerwood, %	Alpha-cellulose, %	0.16
Summerwood, %	Alcohol–benzene extractives, %	−0.35
Summerwood, %	Lignin, %	0.11
Summerwood, %	Yield, %	0.35
WRC, %	Alpha-cellulose, %	0.65
WRC, %	Alcohol–benzene extractives, %	−0.41
WRC, %	Lignin, %	−0.47
WRC, %	Yield, %	0.42
Alpha-cellulose, %	Alcohol–benzene extractives, %	−0.26
Alpha-cellulose, %	Lignin, %	−0.65
Alpha-cellulose, %	Yield, %	0.50
Alcohol-benzene extractives %	Lignin, %	0.16
Alcohol-benzene extractives, %	Yield, %	−0.64
Lignin, %	Yield, %	−0.49
Fiber length, mm.	Specific gravity	0.22
Fiber length, mm.	Alpha-cellulose, %	0.47
Fiber length, mm.	Yield, %	0.49
Fiber length, mm.	Zero span tensile strength, lb./in.	0.53
Specific gravity	Zero span tensile strength, lb./in.	0.12
Alpha-cellulose, %	Zero span tensile strength, lb./in.	0.48
Yield, %	Zero-span tensile strength, lb./in.	0.44
Compressionwood, %	WRC, %	−0.60
Compressionwood, %	Alpha-cellulose, %	−0.46
Compressionwood, %	Fiber length, mm.	−0.44

with one another, a better picture of the influence of each individual property can be obtained from a multiple regression analysis, the results of which are given in Table IV.

A consideration of the partial regression coefficients is particularly interesting because it shows that it is not necessary to include all measurements for a fairly accurate prediction of yield. The per cent lignin, the per cent extractives, and the specific gravity account together for the major part of the predictable variation, although the water-resistant carbohydrates and the alpha-cellulose are significantly correlated with yield. If only three determinations are used for the prediction of yield, alpha-cellulose could be substituted for lignin with only a small loss of accuracy. Including both measurements is, however, quite inefficient because of the strong correlation between them.

The micropulps do not provide enough material for a complete beater evaluation. To obtain an estimate of fiber strength, the handsheets were subjected to a zero-

Table IV. Multiple Regression of Yield on a Number of Selected Variables

Independent variable	*Partial standard regression coefficient*
Specific gravity	0.205
Summerwood	0.149
WRC	−0.054
Alpha-cellulose	0.019
Alcohol–benzene extractives, %	−0.491
Lignin, %	−0.394
Multiple correlation coefficient $R = 0.803$	

Table V. Multiple Regression of Zero-Span Tensile Strength on a Number of Selected Variables

Independent variable	*Partial standard regression coefficient*
Fiber length, mm.	0.305
Specific gravity	−0.244
Alpha-cellulose, %	0.349
Yield, %	0.233
Multiple correlation coefficient $R = 0.634$	

span tensile-strength test. This test is performed with a special set of jaws, so designed that the observed tensile strength is almost surely a measure of fiber strength, as shown by Van den Akker, *et al.* (*6*). Fiber strength, fiber length and slenderness, and fiber bonding are important factors influencing sheet strength. Since fiber strength is less dependent than bonding upon processing variables, in this simplified procedure zero-span tensile strength was chosen for measurement. Fiber length is known to be associated with fiber strength rather strongly, as is again borne out by these data. From the standpoint of tree improvement it is also of importance to know how factors affecting yield influence fiber strength. The correlation coefficients of the properties which might be of importance are included in Table III. From these data, it appears that only fiber length, the per cent alpha-cellulose and the yield have a significant influence. The multiple regression was also calculated for these variables and is shown in Table V.

Of the factors influencing the zero-span tensile strength, fiber length, specific gravity, alpha-cellulose content, and water-resistant carbohydrates appear to have the strongest influence. The negative regression coefficient indicates that if all other factors are kept constant, an increase in water-resistant carbohydrates tends to reduce the fiber strength. This is understandable, however, if one considers that when alpha-cellulose content is kept constant, an increase in water-resistant carbohydrates reflects an increase in hemicellulose content, which does not contribute to fiber strength. It will be of interest to verify this experimentally.

In evaluating the results of a study like the one just described, the most outstanding feature always appears to be the large amount of variation from tree to tree one encounters. This even turned out to be true for an old field stand which should be more uniform than average because of the rather uniform site conditions and the relatively few parents which probably provided the seedlings for the stand. It is also very rewarding to note that the various analyses carried out separately confirm each other, giving additional evidence of the reliability of data obtained from cores. Of the properties related to the anatomy of the wood, fiber length especially shows up as important in its relation to fiber tensile strength. Of the chemical properties, differences in per cent lignin, per cent alpha-cellulose, and per cent extractives all contribute to differences in pulp yield. Since the per cent alpha-cellulose and the per cent lignin are fairly strongly correlated, it is rather inefficient to carry out both analyses on the same samples as a measure of potential pulp yield and a choice between the two methods should be made on the basis of the desired accuracy, cost, available equipment, and similar considerations.

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Nitration of Cellulose in Anhydrous Mixtures of Nitrogen Tetroxide and Hydrogen Fluoride

IRA T. CLARK and M. A. MILLETT

An anhydrous mixture comprising 30 to 40% nitrogen tetroxide dissolved in liquid hydrogen fluoride was found to be an effective nitrating agent for wood cellulose, cotton linters, and a number of other carbohydrate materials. Nitrations were carried out over the temperature range of −10 to +12° C. in polyethylene or Teflon equipment. Following removal of the spent acid by centrifugation, the nitrate esters were readily stabilized to an acceptable level by washing and boiling in water for 1 to 2 hr. A reasonable degree of stability was attained by simply evaporating the absorbed mixed acids. Because of the mild stabilization requirements, the D.P. of the nitrates was only moderately reduced from that of the starting cellulose. The process lends itself to the nitration of cellulose in sheeted form as well as to the conventional shredded or fluffed fibers. Nitration on a continuous rather than a batch basis is thus a possibility.

THE PRINCIPAL commercial method for preparing nitrocellulose is based on the use of mixtures of sulfuric and nitric acid. A disadvantage of the method is the difficulty in removing traces of unstable reaction products, primarily cellulose sulfate. Methods that avoid the use of sulfuric acid have been studied and found in some cases to yield easily stabilized nitrocellulose. These methods have been described by Miles (*1*).

In the present investigation, mixtures of liquid anhydrous nitrogen tetroxide and liquid anhydrous hydrogen fluoride were used to prepare nitric acid esters of cellulose. The nitration was easily accomplished by immersing the cellulosic material in the liquid anhydrous mixture for a few minutes. The nitrocellulose was insoluble in the nitrating mixture and was freed of the liquid by filtering or centrifuging. Residual reagent was removed by air drying at room temperature or by washing the nitrocellulose a few times with water.

Studies were made of the effects of several reaction variables on the nitrogen content, degree of polymerization (D.P.), and heat stability of the nitrocellulose product. Commercial grade, oven-dried, fluffed cotton linters were used in the experiments. They had a viscosity of 12.9 cp. as a 0.5% solution in cupriethylenediamine solution; equivalent to a D.P. of 1116.

Highest nitrogen levels were obtained when the nitrating mixture contained about 30% of nitrogen tetroxide and 70% of hydrogen fluoride. Figure 1 shows this effect for cotton linters nitrated for 10 min. at 12°C. with mixtures whose nitrogen tetroxide content varied from 10 to 50%. Use of a mixture containing 30% nitrogen tetroxide resulted in nitrocellulose with a nitrogen content of 13.4%, a D.P. of 750, and a stability of 16 min. as determined by the 134.5°C. heat test (*2*). The use of nitrating mixtures containing greater or lesser quantities of nitrogen tetroxide than this optimum composition resulted in products of lower nitrogen content that were incompletely soluble in acetone.

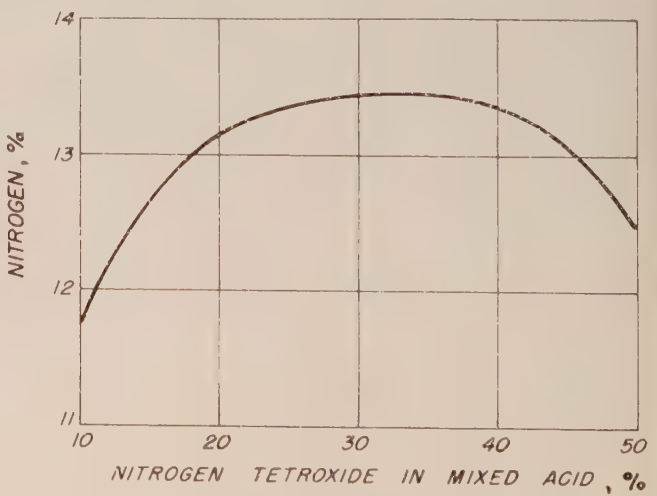

Fig. 1. The effect of mixed acid composition on the nitration of cotton linters

The effects of several conditions of time at −10, 0, and 12°C. were determined on the properties of nitrocellulose that was prepared with mixtures containing 30% of nitrogen tetroxide and 70% of hydrogen fluoride. These are shown in Fig. 2. At −10°C.,

IRA T. CLARK, Chemist, and M. A. MILLETT, Chemist, Forest Products Laboratory, maintained at Madison, Wis., in cooperation with the University of Wisconsin. Forest Service U. S. Department of Agriculture.

12.5% nitrogen was introduced in 1 min., and slightly more at 0 and at 12°C. in that interval. Near-equilibrium conditions were reached after about 10 min. at 0 and 12°C. and a nitrogen content of 13.4%. Thereafter, the nitrogen content increased only slowly, attaining 13.66% nitrogen in 90 min. at 0°C. This

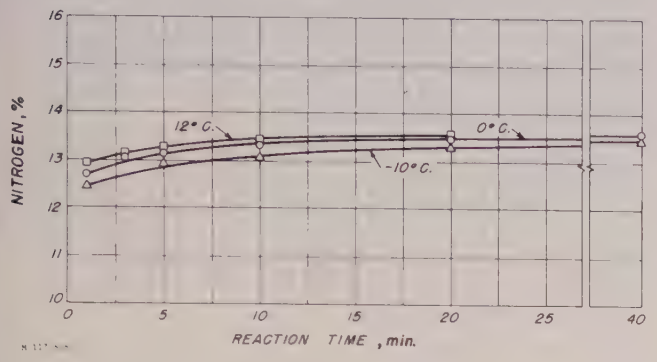

Fig. 2. The effect of time and temperature on the nitration of cotton linters

was not increased in a 6-hr. nitration at 0°C. Nitration at −10°C. proceeded more slowly than at 0 or 12°C. and required about 40 min. to reach a nitrogen content of 13.4%. Theoretical yields of 97 to 99% were obtained at all temperatures. Nitrocellulose prepared at all three temperatures had stability values of between 15 and 18 min. after washing acid-free with distilled water, with the lower temperatures providing the better stability values. Nitrocellulose prepared at −10 and 0°C. had a D.P. of 750 to 850, and that prepared at 12°C. a D.P. of 500 to 600.

The use of several ratios of nitrating mixture to cellulose was studied. Weight ratios of 28.4 parts of acid mixture to 1 part of cotton linters were just as satisfactory as 114 to 1. The smaller quantity was about the minimum of liquid mixture that would cover the linters. This provided a ratio of 10 moles of nitrogen dioxide per mole of cellulose hydroxyl. These data are shown in Table I.

The nitrate esters prepared by this reaction were relatively stable. There was no apparent fire hazard in removing the acid mixture by centrifuging or air-drying. A nitrocellulose sample that was only air-dried to free it of acid has been stored for over a year without apparent decomposition. Stability values of 15 to 18 min. were normally obtained by air-drying or washing the nitrocellulose acid-free with distilled water. By boiling the nitrate esters in hard water for 2 or 4 hr., stability values of 33 and 36 min., respectively, were obtained. Because nitrocellulose prepared by this method does not require the extensive stabilization treatments necessary in present commercial processes, higher molecular weight levels are retained.

The nitrogen tetroxide–hydrogen fluoride reagent has been used to nitrate other forms of cellulose and other carbohydrates. These data are given in Table II. The nitration of wood pulp resulted in nitrocellulose comparable to that from linters, with a slightly lower D.P. The reagent was used to nitrate pulp sheets 0.01 in. thick. The product had 13.16% nitrogen content, 25 min. stability value, and a D.P. of 985. It was similar to the original cellulose sheet in appearance, flexibility, and tensile strength.

Table I. The Effect of Varying the Ratio of Acid-to-Cellulose on the Nitration of Cotton Linters[a]

Experiment no.	Grams mixed acid / Grams cellulose	Moles NO_2 / Moles cellulose OH	Nitrocellulose product: Nitrogen, %	Stability,[b] min.	D.P.	Theoretical yield %
44	114	40	13.20	16	770	100.1
46	86	30	13.17	13	750	98.5
30	60	20	13.02	18	746	98.0
45	58	20	13.20	14	728	99.4
83	42.5	15	13.28	16	740	97.2
84	28.4	10	13.19	17	718	95.0

[a] Nitration conditions were as follows: 4.0 g. of oven-dried linters at 0°C or 5 min. in 30% N_2O_4–70% HF.
[b] 134.5°C. heat test (stabilized only by washing free of acid.).

LABORATORY PREPARATION

The reagent for a typical experiment was prepared as follows: 67.5 g. of liquid anhydrous nitrogen tetroxide (1.47 moles of NO_2) was cooled to 0°C. in a covered, hard polyethylene beaker of 400-cc. capacity. It was then poured slowly with stirring, into 162.5 g. of liquid anhydrous hydrogen fluoride that had been previously cooled to about −30°C. in a covered, 1-liter, hard polyethylene beaker. A mild reaction occurred that evolved some fumes (the reaction can be very brisk with reagents at near room temperature). The resulting mixture had a temperature of about 30°C. and it was cooled to 0°C. The nitration was performed in the beaker, immersed in crushed ice. A small polyethylene refrigerator food bag with a teflon stirring rod thrust through it furnished a snug fitting cover, excluding air and moisture.

Four grams of oven-dried cellulose (linters, fluffed fibers, or shreds) were immersed in the cold reagent, the cover put in place, and the reaction stirred for 10 min. The reaction mass was poured through a cone of fine-mesh monel screen into a 1-liter polyethylene beaker. The nitrocellulose in the screen was allowed to drain momentarily and then separated from most of the adsorbed acid mixture by centrifuging it in a monel screen tray that was supported in a polyethylene centrifuge bottle. The resulting nitro pulp was teased apart with nickel forceps and spread on a polyethylene sheet in a hood draft to air-dry, or was drowned in small portions in ice water. The drowned nitrocellulose product was washed with distilled water in a Buchner funnel until the wash water was acid-free. After air-drying overnight, 7.0 g. of nitrocellulose containing about 0.5% moisture were recovered.

Table II. Nitration Products[a]

Carbohydrate	Nitration time, min.	Nitrogen, %	Stability[b] min.	D.P.
Gumwood pulp	5	13.01	17[c]	348
Sulfite pulp	10	13.50	17	500
Cotton linters	10	13.38	17	755
Cotton linters	5	13.18	33[d]	704
Cotton linters	5	13.18	36[e]	650
Pulp sheet 0.01 in. thick	10	13.16	15	985
Pulp sheet 0.01 in. thick	10	13.16	25[d]	985
Rayon	10	12.27	8	157
Ramie	10	12.35	12	1090
Amylopectin starch	20	13.16		200
Alginic acid (poly β-mannuronic acid)	10	9.26		

[a] Nitration conditions: 0°C. in 30% N_2O_4–70% HF. Stabilized by water washing acid-free.
[b] 134.5°C. heat test.
[c] Nitrocellulose was air-dried without water washing.
[d] Stabilized by boiling 2 hr. in hard water.
[e] Stabilized by boiling 4 hr. in hard water.

Nitrogen content was determined by the nitrometer method (*2*). Degree of polymerization was determined from the relationship:

$$\text{D.P.} = \frac{[n]}{k_m} \qquad (1)$$

using a Staudinger constant k_m of 0.012 (*3*). Values of intrinsic viscosity were calculated by the use of the Baker-Philippoff equation:

$$[n] = 8\,(n_r^{1/8} - 1)/c \qquad (2)$$

Relative viscosity values n_r, of 0.25 g.-per-dl. solutions of nitrocellulose in acetone were determined in capillary viscometers at 25°C.

SAFETY PRECAUTIONS

Precautions must be observed in handling hydrogen fluoride and nitrogen tetroxide, since they are toxic, corrosive materials, though no more so than many others commonly used. Face masks, neoprene gloves, and protective equipment, and well-ventilated hoods are required. Information regarding safety equipment, handling procedures, physiological effects, and treatment of injuries, is available from the manufacturers of hydrogen fluoride and nitrogen tetroxide and should be carefully studied before undertaking their use.

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Interreactions of Smelt and Water

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An investigation was undertaken to study the physical and chemical reactions involved when a liquid comes into intimate contact with molten smelt. Synthetic smelts of sodium carbonate, sodium sulfate, sodium sulfide, and mixtures of these were produced in a small gas-fired furnace and then brought into contact with water or green liquor. This generally caused a reaction of explosive proportions, whose magnitude depended on the concentration and temperature of the sodium sulfide of the smelt. The chemistry of these explosions when sodium sulfide is present involves the generation of hydrogen according to the typical equation for the sodium sulfide water reaction: $Na_2S + 4H_2O \rightarrow 4H_2 + Na_2SO_4$.

During the many years of operation with the alkaline processes of making pulp for the production of paper, the industry has been cognizant of the care that must be taken to prevent the intimate contact of smelt and water. The introduction of the water wall furnace as an integral part of the heat absorbing equipment to replace the refractory smelter and the water-cooled tuyeres was a major step in reducing the possibility of such contact. However, the possibility still exists, particularly during the preparation of green liquor in the dissolving tank.

Realizing these potential hazards, the Babcock & Wilcox Co. has conducted studies at their Research Center in an effort to determine the chemical and physical reactions between smelt and water. The results of these studies indicate that the reaction between smelt from the soda process with water is predominantly physical in the rapid generation of steam, and the reaction of smelt from the kraft process and water is predominantly chemical, as represented by the equation:

$$Na_2S + 4H_2O \rightarrow 4H_2 + Na_2SO_4$$

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DESCRIPTION OF APPARATUS

In conducting these studies, the test equipment was arranged according to the diagram shown on Fig. 1. The furnace consisted of an 18-in. o.d. standard pipe, 6 ft. long, having a flanged top with a 6-in. diam. gas outlet. The entire inside was lined with $4^1/_2$ in. of refractory material. The furnace was fired by two separately controlled premix gas burners to produce the necessary heat for fusing the various chemicals. A predetermined quantity of water from a pressure chamber was injected beneath the smelt in the furnace at 450 p.s.i. Water flow was controlled by means of a quick acting valve manually operated by means of a 40-ft. reach rod.

Wet gas samples were obtained by trapping a quantity of gases in a specially constructed gas sampler following each explosion, as shown in Fig. 1. Two of these samplers, at different elevations in the furnace were used to trap gas samples following the initial explosion. A third sampler, near the bottom of the furnace, was used to collect a sample of gas should a second explosion occur. The water used in the gas sampling apparatus was saturated with carbon dioxide to

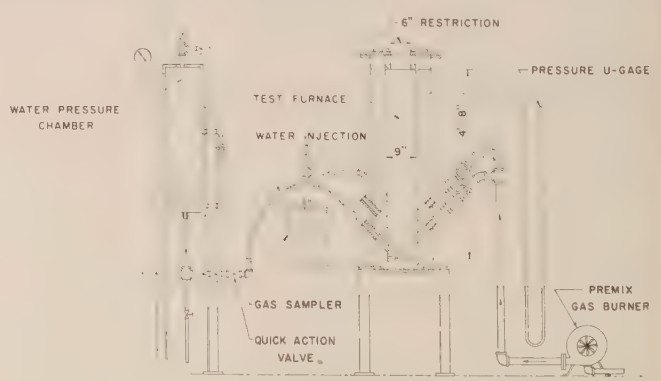

Fig. 1. Disposition of test equipment

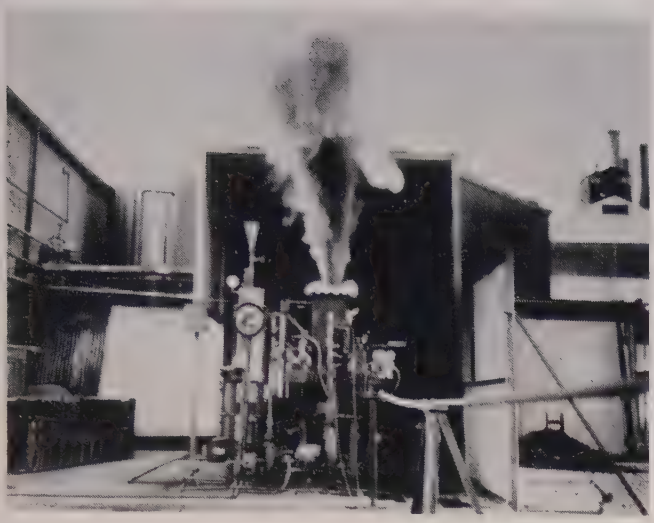

Fig. 2. The assembled equipment during tests

prevent the absorption of carbon dioxide from the gas sample collected.

A manometer connected into the furnace wall, near the top, was used for comparing the relative pressure of the explosive reactions. Smelt temperatures were measured with an optical pyrometer. A standard pressure gage and a sight glass were calibrated to indicate the pressure and the quantity of water injected into the smelt.

Sound recording equipment and movie camera were used for obtaining a record of the explosions during each test. It was apparent from preliminary tests that sound movies would be necessary to determine the color and number of the explosions and the time intervals between delayed explosions. A clock with a sweep second hand was within the view of the camera to record the duration of the eruptions and the intervals between delayed explosions. A Bailey Pyrotron was used to record the resultant gas temperature of each explosion. Figure 2 shows the assembled equipment.

TEST PROCEDURE

The furnace was fired for approximately 1 to 2 hr. until uniformly heated to about 2000°F. The charge to yield 20 lb. of smelt of the desired composition was weighed and packed in paper bags, about 2 lb. per bag. These were dropped into the top of the furnace as rapidly as the melting proceeded, and the smelt was brought to a temperature somewhat higher than that desired for the test. The gas and air were then shut off and the decreasing smelt temperature was observed carefully with an optical pyrometer until it was within the range 50 to 100°F. above the temperature required for the individual experiments. A sample of the smelt was taken for subsequent analysis and allowed to cool slowly in the absence of air. The valves on the two primary gas samplers were cocked *open*, and the water injection tube was inserted underneath the smelt and

Table I. Summary of Data

Test no.	Composition, % Na_2S	Na_2CO_3	Na_2SO_4	Weight of chemicals, lb.	Weight of coke, lb.	Smelt temp., °F.	Distilled water: Amt. added, gal. underneath smelt	Distilled water: Temp., °F.	Distilled water: Pressure, p.s.i.g.	Explosion pressure, in. H_2O	Hydrogen, % by volume	Remarks
35-1	..	100	..	20	..	1600	1	212	450	8.0	0.7	Steam–physical reaction
35-2	..	100	..	20	..	1800	1	212	450	17.6	0.7	Steam–physical reaction
35-3	..	100	..	20	..	2000	1	212	450	16.0	..	Steam–physical reaction
36-1	..	..	100	20	..	1600	1	212	450	4.8	0.2	Steam–physical reaction
36-2	..	..	100	20	..	1800	1	212	450	22.4	0.6	Small pop
36-3	..	..	100	20	..	2000	1	212	450	25.6	3.7	Flame–loud pop
37-1	100	..	..	20	..	1600	1	212	450	32.0	1.5	Flame–loud explosion
37-2	100	..	..	20	..	1800	1	212	450	50.4	5.6	Flame–loud explosion
37-3	100	..	..	20	..	2000	1	212	450	66.4	16.9	Flame–loud explosion
38-1	20	75	5	20	..	1600	1	212	450	4.8	2.3	Steam–loud pop
38-2	20	75	5	20	..	1800	1	212	450	4.8	3.0	Steam–loud pop–42 sec.
38-3	20	75	5	20	..	2000	1	212	450	43.2	5.1	Delay–second pop delay, second explosion–10 sec. delay, third explosion
40-1	..	100	..	20	20	1600	1	212	450	20.4	1.7	Steam–physical reaction
40-2	..	100	..	20	20	1800	1	212	450	32.0	6.7	Steam–sharp explosion
40-3	..	100	..	20	20	2000	1	212	450	25.6	5.3	Steam–dull explosion
41-1	..	..	100	20	20	1600	1	212	450	16.0	2.1	Steam–sharp explosion
41-2	..	..	100	20	20	1800	1	212	450	51.2	5.4	Flame–rapid, double explosion, loud
41-3	..	..	100	20	20	2000	1	212	450	70.5	11.5	Flame–two very loud rapid explosions
42-1	100	..	..	20	20	1600	1	212	450	6.4	1.1	Flame–small pop
42-2	100	..	..	20	20	1800	1	212	450	44.8	5.7	Flame–loud explosion
42-3	100	..	..	20	20	2000	1	212	450	44.8	6.8	Flame–three rapid explosions
42-4	100	..	..	20	20	2000	1	212	450	25.6	16.4	Explosion–dull
42-5	100	..	..	20	20	2000	1	212	450	64.0	12.8	Flame–two rapid explosions, loud
43-1	20	75	5	20	20	1600	1	212	450	17.6	6.7	Flame–rapid double explosion
43-2	20	75	5	20	20	1800	1	212	450	40.0	13.6	Flame–loud explosion
43-3	20	75	5	20	20	2000	1	212	450	49.5	9.2	Flame–two rapid, loud explosions
44 1	20	75	5	20	..	1600	[a]	[a]	[a]	91.2	4.9	Two very loud explosions
44-2	20	75	5	20	..	1800	[a]	[a]	[a]	83.2	5.2	Small explosion, then three rapid, sharp explosions
44-3	20	75	5	20	..	2000	[a]	[a]	[a]	108.8	7.9	Two rapid, very loud explosions

[a] Tests 44-1, 2 and 3 injected 1 gal. green liquor at 450 p.s.i.g. (180°F.) (17.0° Bé at 60°F.) underneath smelt.

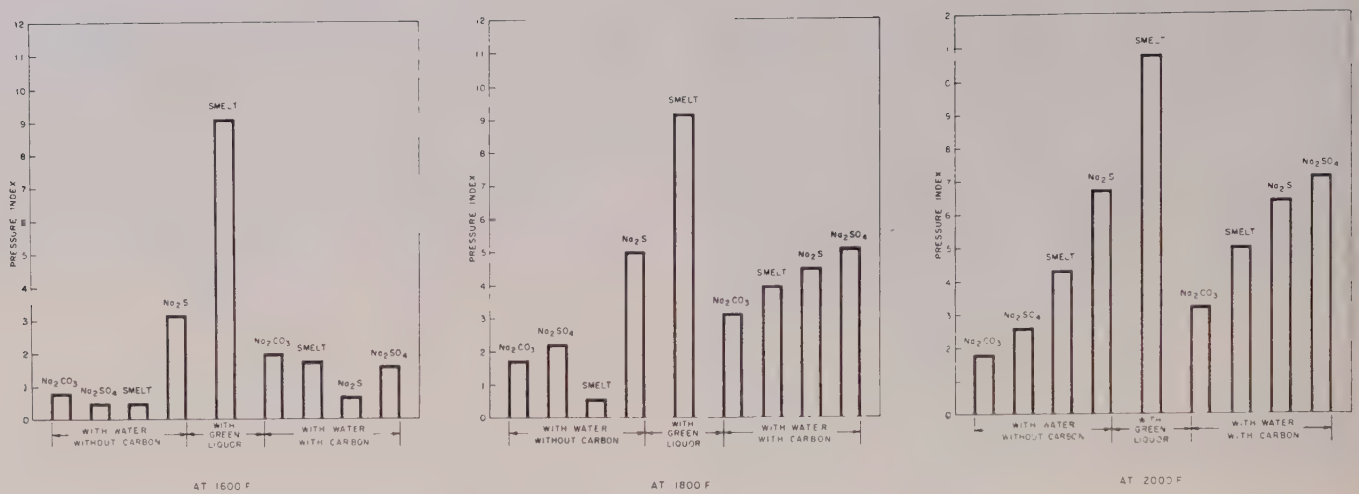

Fig. 3. The reactions of molten alkalies with liquid

locked in position. The reservoir was checked for 450 p.s.i. air pressure and proper water level. The tape recorder was started, a warning whistle was blown, and the movie camera was then started. The temperature recorder was energized and the 40-ft. rod controlling the water valve was pulled open and then closed, releasing 1 gal. of water. Immediately after the initial explosion, the quick-acting valves on the primary gas samplers were closed, and the valve on the third gas sampler was opened in anticipation of a second explosion.

The manual winding on the movie camera provided motion pictures for about 1 min. and 20 sec. at the rate of 16 frames per second. As soon as it was safe to approach the furnace, the injection tube was removed and, when possible, another sample of the smelt was taken to determine its composition after the reaction had taken place. This was not always possible because at times the intensity of the explosion was such that most of the smelt was blown out of the unit. The manometer reading was recorded. The gas samples were transferred from the samplers to glass sample tubes for subsequent analysis.

The furnace was fired again and recharged for the next test. Usually the order of the tests in a series was at smelt temperature levels of 1600, 1800, and 2000°F.

The smelt composition for each of these series of tests was as follows:

Series			
35	100% Na_2CO_3		
36	100% Na_2SO_4		
37	100% Na_2S		
38	20% Na_2S	75% Na_2CO_3	5% Na_2SO_4

Table II. Summary of Chemical Analysis

Test no.	*Composition, %* Na_2S	Na_2CO_3	Na_2SO_4	*Temp., °F*	*Explosion pressure, in. H_2O*	*Carbon dioxide,[b] %*	*Oxygen, %*	*Carbon monoxide, %*	*Illuminants, %*	*Hydrogen, %*	*Hydrocarbons as CH_4, %*	*Nitrogen by difference, %*
35-1	...	100	...	1600	8.0	3.4	13.9	0.9	Nil	0.7	0.4	80.7
35-2	...	100	...	1800	17.6	4.3	8.7	0.3	Nil	0.8	0.3	85.6
36-1	...	...	100	2000	4.8	24.2	12.0	0.4	Nil	0.2	Nil	63.2
36-2	...	...	100	2000	22.4	7.0	11.8	Nil	Nil	0.6	0.1	80.5
36-3	...	...	100	2000	25.6	9.8	4.1	2.2	Nil	3.7	0.9	79.3
37-1	100	...	...	1600	32.0	7.1	11.1	0.3	Nil	1.5	0.3	79.7
37-2	100	...	...	1800	50.4	0.1	7.7	Nil	0.1	5.6	Nil	86.5
37-3	100	...	...	2000	66.4	Nil	4.4	0.3	0.1	16.9	0.3	78.0
38-1	20	75	5	1600	4.8	0.8	9.4	0.6	0.1	2.3	1.2	85.6
38-2	20	75	5	1800	4.8	5.4	5.5	1.0	0.3	3.0	1.0	83.8
38-3	20	75	5	2000	43.2	0.8	9.1	0.1	Nil	5.1	0.4	84.5
40-1	...	100 + C	...	1600	20.4	3.0	10.0	0.1	0.3	1.7	Nil	84.9
40-2	...	100 + C	...	1800	32.0	1.9	9.3	0.4	0.5	6.7	0.4	86.8
40-3	...	100 + C	...	2000	25.6	4.0	8.5	0.9	0.1	5.3	0.9	80.3
41-1	...	...	100 + C	1600	16.0	0.7	10.7	0.1	Nil	2.1	0.6	85.8
41-2	...	...	100 + C	1800	51.2	1.4	8.7	0.1	0.4	5.4	0.4	83.6
41-3	...	...	100 + C	2000	70.5	2.4	5.4	0.5	Nil	11.5	0.6	79.6
42-1	100 + C	...	...	1600	6.4	3.3	5.8	1.0	0.5	1.1	1.5	86.8
42-2	100 + C	...	...	1800	44.8	7.7	0.6	0.5	0.4	5.7	0.1	85.0
42-3	100 + C	...	...	2000	44.8	3.5	3.5	1.7	Nil	6.8	0.4	84.1
42-4	100 + C	...	...	2000	25.6	6.1	1.7	1.7	Nil	16.4	2.4	71.7
42-5	100 + C	...	...	2000	64.0	4.1	9.3	0.4	Nil	12.8	1.5	71.9
43-1	20 + C	75	5	1600	17.6	2.7	7.3	1.1	Nil	6.7	0.5	81.7
43-2	20 + C	75	5	1800	40.0	3.9	2.3	0.4	Nil	13.6	1.6	78.2
43-3	20 + C	75	5	2000	49.5	3.0	4.6	1.2	Nil	9.2	0.2	81.8
44-1[a]	20	75	5	1600	91.2	0.9	11.7	0.5	Nil	4.9	0.3	81.7
44-2[a]	20	75	5	1800	83.2	4.0	7.9	0.5	0.1	5.2	0.3	82.0
44-3[a]	20	75	5	2000	108.8	1.7	10.1	0.4	0.1	7.9	0.3	79.5

[a] Injected green liquor.
[b] Includes SO_2, if present.

Table III. Summary of X-ray Analysis

Test no.	Sample taken	Na_2S, %	Na_2CO_3, %	Na_2SO_4, %	Temp., °F.	X-ray analysis (crystalline constituents) Major	Medium	Minor
37-3	Before explosion	100	...	...	2000	$(Na_2SO_4)(Na_2S)$	...	...
37-3	After explosion	100	...	...	2000	Na_2SO_4	Na_2S	...
40-2	Before explosion	...	100 + C	...	1800	Na_2CO_3	...	...
40-2	After explosion	...	100 + C	...	1800	Na_2CO_3	...	...
40-3	Before explosion	...	100 + C	...	2000	Na_2CO_3	...	...
40-3	After explosion	...	100 + C	...	2000	Na_2CO_3	...	...
41-1	Before explosion	...	...	100 + C	1600	Na_2S	...	...
41-2	Before explosion	...	...	100 + C	1800	Na_2S	...	...
41-3	Before explosion	...	...	100 + C	2000	Na_2S	...	...
42-3	Before explosion	100 + C	...	...	2000	Na_2S	...	...
42-3	After explosion	100 + C	...	...	2000	Na_2S	Na_2SO_4	...
42-4	Before explosion	100 + C	...	...	2000	Na_2S	...	...
42-4	After explosion	100 + C	...	...	2000	Na_2S	...	Na_2SO_4
42-5	Before explosion	100 + C	...	...	2000	Na_2S	...	...
42-5	After explosion	100 + C	...	...	2000	Na_2S	Na_2SO_4	...
43-3	Before explosion	20 + C	75	5	2000	Na_2S	...	...
43-3	After explosion	20 + C	75	5	2000	Na_2S	...	...

40 100% Na_2CO_3 + Coke
41 100% Na_2SO_4 + Coke
42 100% Na_2S + Coke

43 20% Na_2S 75% Na_2CO_3 5% Na_2SO_4 + Coke
44 20% Na_2S 75% Na_2CO_3 5% Na_2SO_4

The following precautions seemed expedient to minimize smelt contamination:

I. Distilled water was used for injection into the smelt. (Except in series 44 when green liquor was used.)

II. The furnace was tapped as clean as possible and then washed with water before using a new charge different in composition from the previous charge.

Coke was added in some experiments to simulate the carbon that exists in a recovery unit.

RESULTS

The smelt produced from the incineration of residual liquors of the alkaline pulping industry consists mainly of sodium compounds. In the soda process the major constituent of the smelt consists of sodium carbonate with minute quantities of impurities.

In the kraft process the smelt consists mainly of sodium carbonate, sodium sulfide, and small quantities of unreduced sodium sulfate. The principal sources of the sulfide are the reduction of the sulfate constituents of black liquor and makeup salt cake by carbon in the reducing atmosphere of the recovery furnace. The composition of the smelt varies according to the requirements of the individual mill, and generally is discharged from the recovery furnace at temperatures of 1600 to 2000°F.

The possible chemical reactions in such a situation are innumerable and very complex. A theoretical study of even the most probable reactions was beyond the scope of this investigation. An expedient and practical evaluation, however, seemed to lie mainly in a study of the physical reactions, and in part the chemical reactions of water with the individual constituents of the smelt as well as the smelt itself.

Water and Sodium Sulfide

It is significant that all the tests with water and 100% sodium sulfide produced explosive reactions, as shown in Table I and Fig. 3.

Some of the possible reactions that could take place are represented by the following equations:

1. $Na_2S + H_2O \rightarrow Na_2O + H_2S$
2. $Na_2S + 3H_2O \rightarrow Na_2O + SO_2 + 3H_2$
3. $Na_2S + 4H_2O \rightarrow Na_2SO_4 + 4H_2$

The presence of hydrogen sulfide and sulfur dioxide could have been detected by their characteristic odors in concentrations as small as a few parts per million of air. Since neither was detected in any of the tests it is unlikely that the reactions represented by equations (1) and (2) occurred to any appreciable extent.

Chemical analyses of the gas samples (Table II) taken after the explosions usually showed the presence of hydrogen, and x-ray diffraction studies of the smelt samples (Table III) showed an increased amount of sulfate after the explosions. Analysis showed that, when heated to high temperatures in the absence of coke, some of the sodium sulfide apparently oxidized to the sulfate. When coke was present (Table IV), its reducing action apparently kept most of the sodium sulfide in its original form prior to contact with water. However, some sulfate was formed during the explosion process, thus further substantiating the validity of the reaction outlined by equation no. (3).

Comparison of these data has been consolidated in the form of bar graphs. Figure 3 shows that the indicated pressure, due to the reaction, is definitely higher for combinations containing sodium sulfide than for any other combinations of smelt and water. This becomes significant when it is realized that the combinations with sodium sulfide in solution (green liquor) and sodium sulfide as smelt produce the greatest force.

Figure 3 also shows that the magnitude of the reaction

Table IV. 100% Sodium Sulfide Plus Carbon
Temperature, 2000°F.

Test no.	42-3 before explosion	42-3 after explosion	42-4 before explosion	42-4 after explosion	42-5 before explosion	42-5 after explosion
X-ray analysis (crystalline constituents)						
Major	Na_2S	Na_2S	Na_2S	Na_2S	Na_2S	Na_2S
Medium	...	Na_2SO_4	...	...	...	Na_2SO_4
Minor	...	...	...	Na_2SO_4	...	...

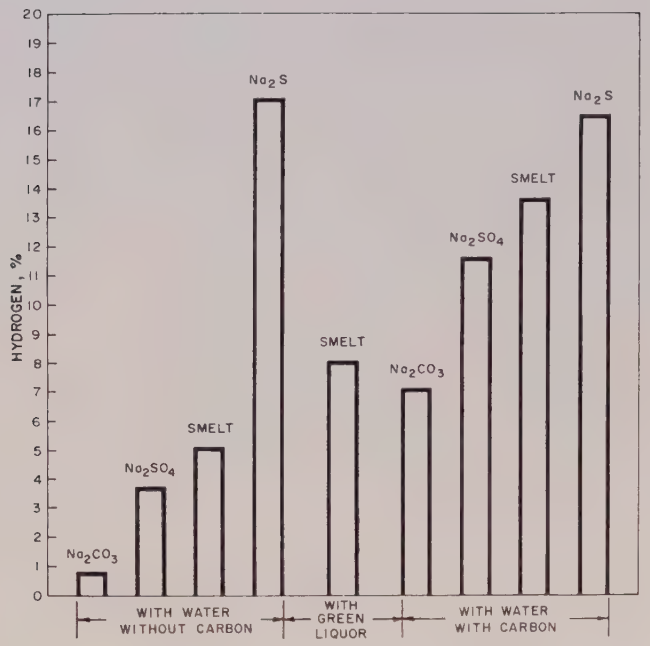

Fig. 4. The reactions of molten alkalies with liquid

between sodium sulfide and water is a function of temperature. The force of the reaction is increased by a factor of two as the temperature of the sodium sulfide is increased from 1600 to 2000°F.

Figure 4 shows that the precentage of hydrogen evolved is greatest when 100% sodium sulfide is reacted with water. The presence of carbon does not appear to increase this percentage, although it seems to have been a contributing factor in other tests.

Water and Sodium Carbonate

The reaction between water and 100% sodium carbonate (series 35) produced manometer readings comparable to those of some of the explosions. It was apparent, however, from the abundant production of vapor and the absence of detonation that these readings were caused mainly by the rapid generation of steam. It was not until coke was introduced with the carbonate (series 40) that detonation occurred and then only at the higher temperatures. It seemed quite probable that such conditions produced a considerable amount of water gas $C + H_2O \rightarrow H_2 + CO$ which either caused the explosion or increased its intensity.

Water and Sodium Sulfate

The tests with water and sodium sulfate showed a variety of reactions, sometimes violent, sometimes not. The reason for these differences in behavior is not always clear. It is true that the reducing atmosphere of the furnace could account for the presence of sulfide, which may have caused the explosions. This is particularly true when the sulfate was melted in the presence of coke and formed sodium sulfide as the major constituent of the smelt, as shown on Table III for series 41. Table II and Fig. 3 show that the magnitude of the explosive pressure under these conditions equaled that of the sulfide reaction. However, Fig. 4 shows that the hydrogen evolution was somewhat less.

It should further be noted, as shown on Fig. 3, that the magnitude of the explosive reaction is a function of temperature. At 1600°F. the pressure was equivalent

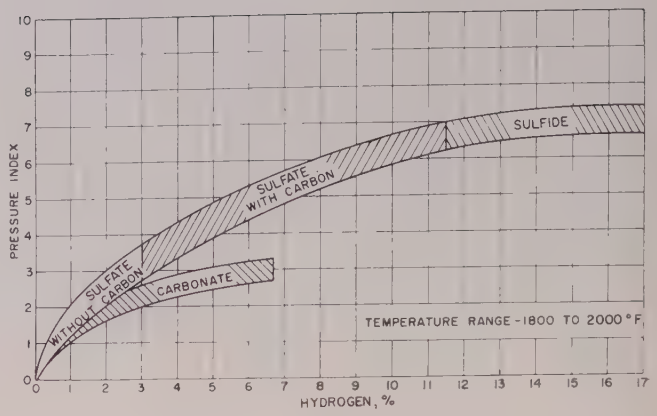

Fig. 5. The reactions of molten alkalies with water

to that of a purely physical reaction, such as that between water and sodium carbonate; whereas, at 2000°F. the forces were equivalent to those produced when water and sodium sulfide react.

Green Liquor and Smelt

To simulate the conditions that could exist in the kraft process, investigations were undertaken to study the reactions when smelt was contacted with green liquor of the same composition. In these experiments the composition of the smelt and green liquor consisted of 20% sodium sulfide, 75% sodium carbonate, and 5% sodium sulfate by weight as sodium oxide. The concentration of the green liquor was 17°Bé.

The results of these studies are shown on Tables I and II and in Fig. 3 and 4. Table I and Fig. 3 indicate that the pressures from these reactions were the highest recorded under any of the conditions tested. It will also be noted that these reaction pressures are higher when the smelt temperature is 2000°F. than when it is 1600°F. Similarly, Table II shows that the amount of hydrogen in the gases increases with the increase in temperature.

SUMMARY

The pertinent data from these studies are summarized by the various curves and tables. These show that:

1. Within a temperature range of 1800 to 2000°F. the pressures developed from the reactions of sulfate without carbon and carbonate smelt both with and without carbon are of about the same magnitude.
2. The pressures developed from the reaction of sodium sulfate and water in the presence of carbon increases as the temperature of the smelt increases.
3. The amount of hydrogen released during the sodium carbonate–water reaction more than doubles when carbon is present. This is probably due to the formation of water gas which results in additional quantities of hydrogen.
4. The hydrogen evolved during the sodium sulfate–water reaction in the presence of carbon ranged between 3.0 to 11.5% by volume, which was considerably higher than either the sulfate–water or carbonate–water reactions which ranged from zero to 6.5%.
5. A further increase in both pressure developed and hydrogen evolved was found for the sodium sulfide–water reaction. This reaction indicated a pressure index of 6.2 to 7.5 and hydrogen evolution in the range of 11.5 to 17% by volume.

CONCLUSIONS

It seems reasonable to conclude from these data that the reactions of smelt from the soda process with water are predominantly physical and are caused by the rapid evaporation of water.

In contrast, the reactions between water and kraft smelt with sodium sulfide present are chemical reactions as represented by the equation $Na_2S + 4H_2O \rightarrow Na_2SO_4 + 4H_2$. Appreciable quantities of sodium sulfate were found in the smelt and high percentages of hydrogen were found in the gases after the reactions and each increased with an increase in temperature of the smelt.

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Testing of Mill Waste Water

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The purposes of testing paper mill waste water are to determine the amount of materials lost, and the pollution load being discharged to the receiving stream. Some of the mechanics of waste-water testing are presented, along with some of the author's experiences in this field. The essential part of any white-water analysis are flow measurement, sampling, analysis, and expression of results. The type of test performed depends on products manufactured, and the requirements of the local water pollution control authority. For cost analysis it is usually necessary to test for suspended solids (fiber and filler) and certain dissolved solids. Regulatory agencies may want to know the temperature, B.O.D., pH, and settleable solids. Unusual circumstances occasionally require methods which have been especially adapted to apply to a special situation, such as the presence of fillers in a state of colloidal dispersion, or partially dissolved solids. The accuracy required in white water testing is usually less than other chemical analyses. Accuracy must be sufficient, however, to satisfy requirements of both cost accounting and regulatory agencies. Each mill must determine the practices best suited to its needs.

TESTING of mill waste water has been practiced for many years in the pulp and paper industry, but only in the past 10 or 15 years has it received special emphasis. There are two reasons for this increasing interest in the testing of mill effluents. One is the realization that vast quantities of raw materials are being lost in the mill sewers, and that analysis of this waste water is the first step toward reclamation. The other is the increased enforcement of antipollution laws by state and federal regulatory agencies, as well as the increased pressure of public opinion. Today, nearly all pulp and paper mills have facilities for testing their waste water. The tests performed depend on the requirements of each individual mill, and the statutes governing waste discharge.

This paper will attempt to show some of the mechanics of waste water testing, as well as to relate some of the author's own experiences in this field. No attempt will be made to outline the standard analyses used, because these are readily obtainable from a number of textbooks and journals on the subject.

Because of the author's limited experience of pulping, the subject matter of this paper will be concerned primarily with paper mill waste. However, much of the information is generally applicable to both types of operations.

White water testing is especially important to paper mills because it reveals directly the amount of raw materials lost in the mill effluent. This knowledge is necessary to justify certain expenditures, such as for retention additives, new equipment, or additional manpower. The most important aspect, however, is that testing provides direct information necessary in controlling these losses, both in the interest of stream improvement and of reduced costs. Realistic control measures are not possible without first determining the extent of control necessary.

Whereas, many mills will test only to determine the amount of fiber and filler lost, proper cooperation with the regulatory agencies most likely will require analyses for Biochemical Oxygen Demand (B.O.D.), total solids, settleable solids, suspended solids, and dissolved solids. Some states even have rigid limits for chloride ion concentration, as well as for the level of toxicity, taste, and odor, for which tests may have to be made.

Regardless of the type of testing done, any complete program consists of four essential steps. These are sampling, flow measurement, analysis, and expression of results. A detailed description of these is given in the following sections.

SAMPLING

No white water analysis can be considered reliable without satisfactory sampling methods and flow measuring devices. Random or "spot" samples can be analyzed with respect to conditions prevailing at any one time. However, results can best be integrated over a specified period of time (usually daily) by the method of composite sampling. By this means, a relatively small sample is taken at controlled time intervals, the resulting composite then being thoroughly mixed, and an aliquot taken for analysis. Such a sample is not necessarily an "average" sample because of the wide variation of conditions that often occur over the sampling period. It is simply referred to as a "composite," and for most purposes is considered a representative sample.

Sampling devices can be simple and crude, or as complex and elaborate as conditions warrant. Samplers can be operated by a simple timing device, or regulated by changes in liquid level or velocity, in order to vary the sampling rate with the flow. If the flow varies

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Fig. 1. A simple dip type sampler for mill sewers

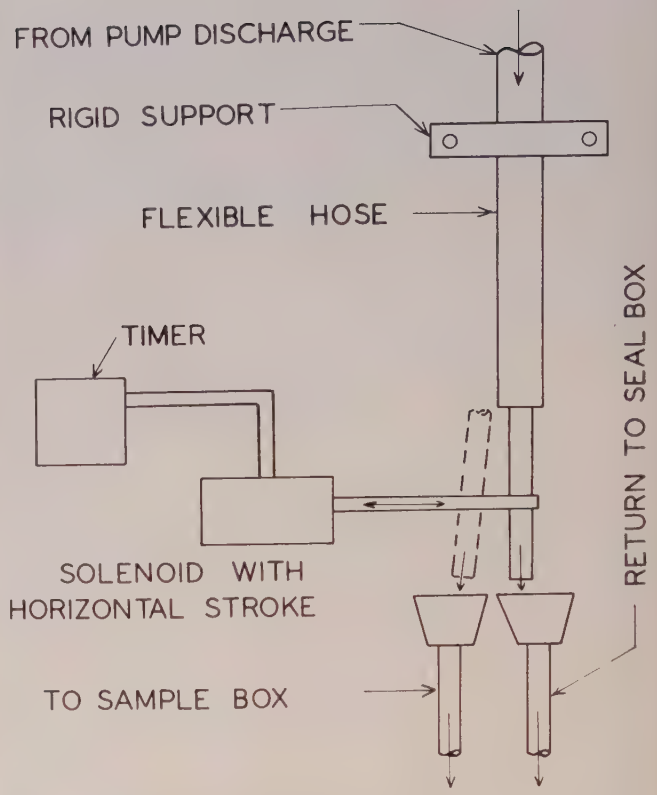

Fig. 2. White water sampler for use where water is to be sampled under pressure

appreciably, a variable rate sampler can be expected to yield a more representative sample.

Figures 1 and 2 show examples of relatively simple and trouble-free samplers. Both types have given excellent service as constant-rate samplers, and are readily adaptable to variable-rate sampling with the installation of controlling apparatus. The sampler in Fig. 1 periodically dips a small sample out of a mill sewer, the amount of sample being roughly proportional to the flow. Certain refinements on this equipment could be made, which would make it a direct proportional sampler. The sampler shown in Fig. 2 must operate off a pump, usually being connected to the vent or other convenient connection. This type is especially adaptable to sampling of clarified white water from savealls, and has shown to be a very serviceable piece of equipment.

In setting up sampling equipment, care should be taken to ensure that the sampling taken will be proportional to the flow, if widely variable flows are to be encountered.

FLOW MEASUREMENT

Flow measurement is vitally important in waste water testing, and a wide selection of devices are available for this purpose. One of the simplest and most reliable is the calibrated weir. Weirs are well suited as temporary means of flow measurement, as well as for permanent installation. Probably the most suitable, if widely variable flows are to be encountered, is the sharp-edge V-notch weir. The quantity q, in cubic feet per second, of water passing over a V-notch weir is given by the equation:

$$q = 2.505 \, (\tan \alpha/2)^{0.996} \, H^{2.47} \qquad (1)$$

where α = angle of the notch.

H = head in feet measured from the vertex of the notch.

Recording and integrating equipment is readily available for use with weirs so that the flow need not be calculated. More complete information on weirs appears in Perry's handbook for chemical engineers (*1*).

A modification of the weir which has gained wide acceptance for flow measurement is the Parshall flume. This is usually a permanent installation and can be readily adapted to paper mill sewers. As with weirs, the flow is a function of the height of liquid surface above the crest of the flume. Recording and integrating equipment is usually associated with the Parshall

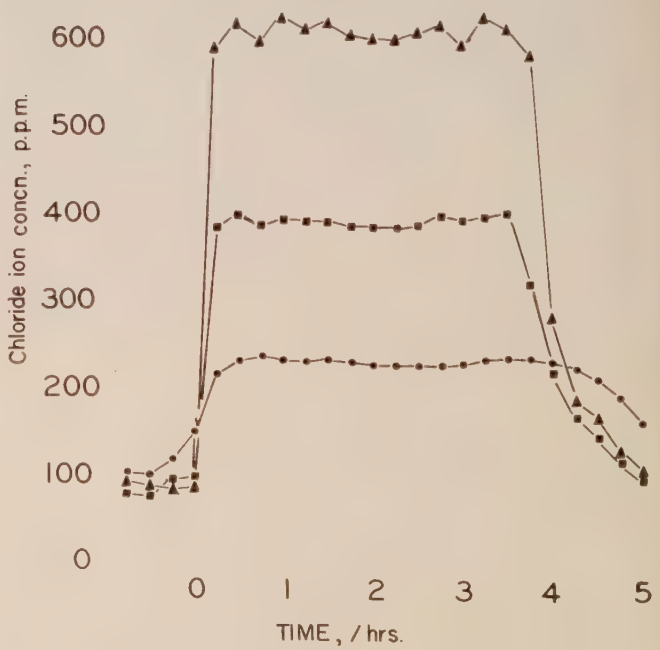

Fig. 3. Chloride ion concentration at three different stations, beginning 30 min. before start of test

flume and may be considered an integral part of such a device. Data on Parshall flumes are available in the United States Department of Agriculture Bulletin No. 843 (*2*).

Flow measurement within pipes is most readily accomplished by determining the velocity of a liquid through a given cross-sectional area. This can be done either with an impeller type meter or with a manometer to measure the differential pressure across an orifice or venturi. Since volume is directly proportional to the velocity, the instruments mentioned above can be graduated directly volumetric units.

All flow measuring devices will require calibration at the time of installation, and some will need checking at subsequent intervals. Probably the most satisfactory means of calibration is by the method of salt dilution, in which a solution containing a known concentration of chloride or other ions is metered into the stream being calibrated. The increase in chloride ions at any point is a function of the concentration of the solution being added, the rate of addition, and volume of flow at that point. Expressed algebraically,

$$V_1 = \frac{V_2 C_2}{C_1 - C_0} \qquad (2)$$

where

V_1 = volume being measured.
V_2 = volume of the salt solution being added.
C_2 = concentration of chloride ion added.
C_1 = concentration of chloride ion at any point in the stream being tested.
C_0 = chloride ion concentration normally present.

For accuracy samples must be taken at definite time intervals, and the results checked against the flows recorded at the same times from the flow-measuring device. Figure 3 shows the results obtained from such a test run on a small stream in central Ohio. Samples were taken at three stations, each curve showing the increase ($C_1 - C_0$) of chloride ion concentration at each station. The limits of accuracy required in this case were low enough to permit sampling every 15 minutes at each of the three stations within a three-mile distance. The results reflect changes in flow resulting from variable discharge from two paper mills; these variations correlate well at each successive station. Had greater accuracy been required, sampling would have been made at shorter intervals. Though this particular test was made outside the mill, similiar calibrations can be made just as easily within the mill, or even on the paper machine if conditions warrant.

ANALYSIS

The actual analysis should be run as soon after sampling as possible. If immediate analysis is not possible, the sample should be stored at a near-freezing temperature. Chemical preservatives should be avoided if possible because they may interfere with results. Unpreserved samples are likely to undergo changes in character as the results of biological activity or slow chemical reaction, and thus yield erroneous results.

The routine tests most likely to be required are thoroughly described in either TAPPI Standards, or the Standard Methods of the American Public Health Association (*3*).

Generally speaking, the limits of accuracy required in the testing of white water are often considerably less than for other chemical analysis. There are several reasons for this. The most obvious reason is the inherent error involved in sampling and flow measurement. For instance, efforts to obtain accuracy to within 0.1% would be unnecessary if the flow measurement were accurate only to within 5%. However, accuracy must be sufficient to satisfy the requirements of cost accounting and standards of the local pollution control authority. Most gravimetric analyses of waste water will have sufficient accuracy when weighing is done to the nearest milligram if the sample is of sufficient size.

As a result, an exception can be made to the procedure for suspended solids as is outlined in Standard Methods, and gravity filtration though a moderately open filter paper may be substituted for a gooch crucible. In mills where many samples are taken each day, the use of filter paper is especially desirable.

In the method recommended in TAPPI Standards a Buchner funnel is used; this has been found to have sufficient accuracy at relatively high solids content. However, discretion should be exercised when testing samples with a very low solids content, especially when fillers are present, since the fine filler particles may be drawn through the filter paper. This has often been found to be true, even after repeated filtrations.

Before any method is adopted, it must be determined whether it satisfies the accuracy requirements. It has been the author's experience that gravity filtration is usually more satisfactory, except where an extremely slow filtration rate is encountered. Better results can then be obtained by using vacuum filtration. Which method is used depends largely on conditions at each individual mill.

Occasionally, unusual circumstances may require analyses for which no procedure has been devised or for which the proper equipment is not readily available. The analyst must be prepared to improvise if need be, in order to obtain the necessary results.

One such case is the determination of suspended solids, when the filler particles (particularly clay and titanium dioxide) are in a state of colloidal dispersion and, therefore, cannot be separated by filtration. Whether this condition is caused by the presence of an organic protective colloid, or an inorganic dispersing agent, means are available for determining the amount of filler present. In each case, samples must first be filtered to remove any nondispersed materials.

There are several different ways which have been found to be satisfactory for the determination of dispersed titanium dioxide. One method is to evaporate a sample to dryness in a 100-ml. crucible, after which a titanium dioxide analyses is performed in accordance with TAPPI Standard T 439 m-44. It may be more convenient to remove the titanium dioxide from suspension by the formation of a dense floc such as produced by the addition of zinc chloride and soda ash. The sample is then filtered, dried and ashed, and a titanium dioxide determination run as explained above. A somewhat simpler method, which has been found to be reasonably accurate, is to compare the unknown sample with a calibrated standard by means of a nephelometer.

Within the range of solids usually encountered, a filter photometer can be adapted for a similar use,

though this is not coincident with the theory of the filter photometer. Whereas, the nephelometer operates on the principle of light scattering by particles suspended in a liquid, the filter photometer uses the principle of filtering a light source of a certain wavelength by absorption in a colored medium.

It is believed that because of the Tyndall effect, and because of the high refractive index of titanium dioxide, this compound scatters the shorter wavelengths of light

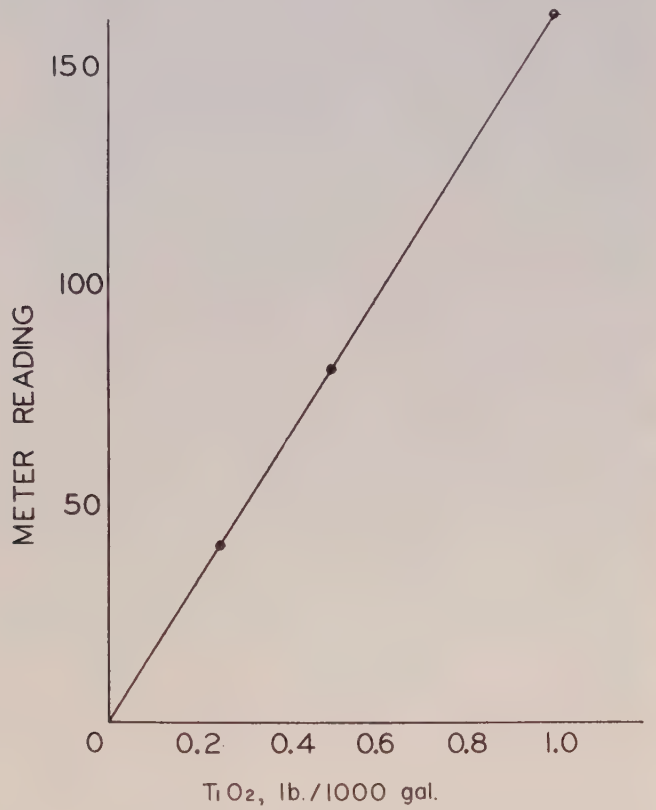

Fig. 4. Relationship of a filter photometer meter reading to dispersed titanium dioxide

in the filter photometer and causes the instrument to react to the longer wavelengths that are transmitted. Consistent results have not been obtained with clay and other fillers, probably because of their low refractive index.

Figure 4 shows the relationship of dispersed titanium dioxide to dial reading on the filter photometer. It can be seen that the curve is linear and that it passes through the origin. If the sample is too dense, it may have to be diluted to give a deflection on the scale, in which case the result will have to be corrected by a dilution factor. This method has been found to be very expedient, and surprisingly accurate. Accuracy has been found to be within $\pm 1\%$. Unless present in relatively large amounts, other fillers appear to interfere very little. Clay, if present in an equal amount, will cause the results to read approximately 10% high.

Dispersed clay, because it lacks the optical properties of titanium, is somewhat more difficult to analyze. However, particles can be readily removed from suspension by the addition of sufficient soda ash and zinc chloride to produce a dense floc. In less than a minute, this floc will start to settle; and a clear supernatant liquid is obtained after about 3 min. Figure 5 shows a sample of clay dispersed in white water. Figure 6 shows the same sample treated as described above and allowed to settle for 3 min. From these pictures the effectiveness of this type of flocculation is evident. If all the clay is not removed from suspension, repeated stirring and settling usually will improve clarity. This phenomenon appears to be primarily a function of occlusion, where the dispersed particles are carried down by the dense floc.

Filtration, drying, and ashing at relatively low temperature (below 1000°F) produces a residue which is essentially clay, zinc oxide, and sodium chloride. Higher temperature (1200 to 1800°F.) ashing tends to produce fusion products of the clay and may lead to erroneous results. Hydrochloric acid is then added to dissolve the zinc compounds, and the sample triturated to eliminate any lumps. The sample is then transferred to a tared gooch crucible and washed with distilled water until the filtrate is free of chloride. The residue is then weighed as clay, and corrected for 15% loss of weight on ashing.

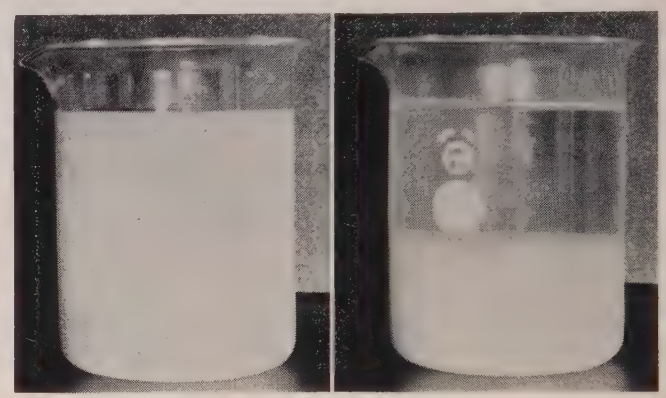

Fig. 5. A sample of white water containing 4.2 lb./1000 gal. of dispersed clay

Fig. 6. The sample shown in Fig. 5 after the addition of zinc chloride and soda ash, agitating, and settling for 3 min.

If both clay and titanium are present, the colorimetric titanium determination is used in addition to the above procedure. The amount of clay is then the total residue less the titanium dioxide, corrected for loss of weight on ashing.

Partially soluble fillers will present a problem to the analyst in determining the amount of materials lost. Of special concern here is the analysis of calcium sulfate in waste water, since this is the only filler material widely used in any significant amounts. Losses of calcium sulfate will appear both as suspended and dissolved solids. To determine the total amount lost, a gravimetric calcium determination should be run on the filtrate from the suspended solids test, and the results added to the nonvolatile suspended solids present.

If other fillers are present, as they often will be, the procedure is not so simple. The calcium sulfate is first separated from other fillers in the nonvolatile fraction by dissolving in ammonium chloride and hydrochloric acid. This portion is then filtered and the calcium ion concentration determined gravimetrically as outlined in Standard Methods.

The total calcium from both these steps less that present as hardness in the water, expressed as calcium sulfate, will be the amount of this filler lost in the waste water.

EXPRESSION OF RESULTS

Proper expression of results is as important as any other part of testing and often little consideration is given to this matter. Lack of consideration of this part of testing may lead to confusion or may reduce the effectiveness of the results. Often, results must be expressed in different terms for different people using the information. For instance, regulatory agencies may wish to be informed of ovendry fiber lost in an effort to determine the pollutional effects on the receiving stream. However, for cost accounting purposes, it is usually more convenient to express fiber on an airdry basis, since pulp is purchased by airdry weight.

Expression of results should always be kept as simple as possible, while still maintaining the intelligence required by the various people using the information.

SUMMARY

Testing requirements may vary considerably, depending on conditions existing at any particular mill and on requirements of pollution control agencies. All testing will, however, include sampling, flow measurement, analysis, and expression of results.

Procedures may vary due to local conditions, and unusual circumstances may occasionally require more involved methods, or even a certain amount of improvisation.

Conditions may also warrant some variation from procedures outlined in TAPPI Standards or Standard Methods, though these should be followed as much as possible. The accuracy required is often less than other chemical analyses, but must satisfy requirements for both cost accounting and pollution control agencies.

With increased emphasis on pollution abatement, as well as efforts by management to keep costs to a minimum, it is certain that the testing of waste water will increase in both scope and importance in the coming years.

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Pressure Cooking for Coating Color Preparation

W. C. BLACK and VERNON L. WINFREY

The degree of dispersion of the granules of a cooked starch paste is a function of the time, temperature, and shear to which the pastes have been subjected. While cooking temperatures above the boiling point of water have been used for starches for laboratory work and certain commercial applications, the improved starch dispersions made possible by the use of elevated cooking temperatures have not been extensively considered for use as paper sizes, coatings, and adhesives. This paper describes equipment which is now available for continuously cooking starches at elevated temperatures and pressures, and describes the changed properties of the pastes prepared with it. The possible utility of such high-temperature-cooked pastes for paper coating adhesives and paper surface sizes is discussed.

The process of cooking the starch at elevated temperatures and pressures is not new. Such a batch cooking or autoclaving operation has long been used by the starch chemist for obtaining the dispersions necessary for the study of starch properties and structure. A continuous modification of the same process has been utilized for years by distillers for the preparation of their mash in a way that facilitates the subsequent treatment with malt enzymes. A continuous process utilizing elevated temperatures and pressures has been adopted by much of the confectionery industry for gelatinizing starch in the presence of a rather high concentration of sugar for the preparation of gum candies. Similar techniques are also currently being used for the preparation of materials as varied as laundry starches, pie crusts and fillings, marmalade, and adhesives.

Recently consideration has been given to the investigation of and possible utilization of the changed properties imparted to a starch paste by such a process in the field of paper sizing and coating.

THE MECHANISM OF STARCH GELATINIZATION

In order to understand the operation of a continuous pressure cooker and to explain some of the results obtainable with it, it is first necessary to understand in a general way what takes place when starch "cooks" or "gelatinizes."

In the normal growth process of the plant starch is laid down in tightly packed molecular bundles or granules consisting of a series of layers or growth rings deposited around the central hilum. In addition to the laminar structure it is believed that within any layer there is also a radial orientation of the molecules outward from the center. This radial alignment of the straight chains and of linear fragments of the branched chains facilitates a lateral association of adjacent molecules and this occurs to the extent that large numbers of highly associated "micelles" or semicrystalline areas are formed. These areas, combined with a degree of natural interlacing or entanglement of the rather large starch molecules, cause the starch granule to be quite rigid and relatively insoluble in water. While it is believed that water can penetrate into the more porous amorphous areas separating the crystallike micelles, its effect on the granule itself is negligible.

When the temperature of a starch slurry is raised to the point known as the "gelatinization temperature"

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the associative tendency of the starch molecules is gradually reduced or replaced by hydration so that the granule begins to lose its rigid nature and tends to swell tangentially. As the temperature is raised the swelling continues until a swollen balloon-like structure results consisting of a hydrated network of starch molecules held together by the more resistant micelles. At this point the granules are somewhat elastic and fragile enough to be fragmented by even moderate shear.

As the granules swell their increased resistance to flow becomes apparent as an increase in viscosity of the suspension. When the swollen granules fragment, the viscosity is reduced. It should be remembered that starch granules are not all alike but vary considerably in size, shape, maturity, etc., and hence do not all swell at the same temperature or rate. Actually starches have a gelatinization temperature *range* rather than a

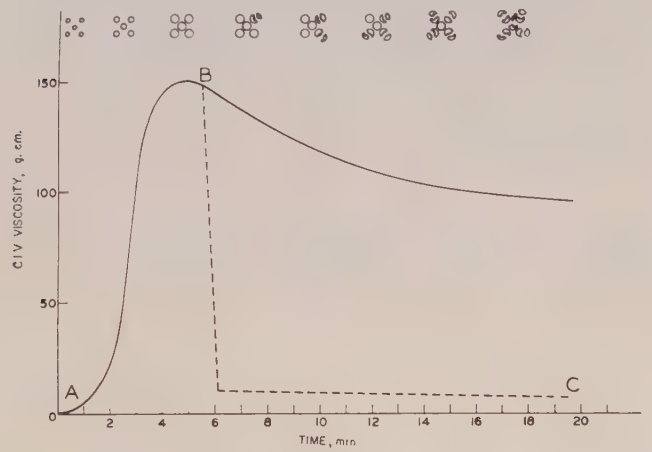

Fig. 1. Cooking curve for 6% unmodified corn starch. Water-bath temperature = 92°F.

Broken line represents paste subjected at point *B* to action of Waring Blendor for 1 min.

gelatinization *point*, and the indicated viscosity of a paste at any time is a function of the average degree of granule swelling and fragmentation which has taken place up to the time of the viscosity reading.

The changes that take place are apparent in the paste viscosity curves obtained on a continuous recording viscometer such as the Corn Industries viscometer or the Brabender Amylograph. These instruments heat an agitated starch slurry at a controlled rate and record the apparent viscosity during the cooking cycle. A representative cooking curve for a 6% unmodified cornstarch paste is shown in Fig. 1. Above the curve is a crude representation of the relative size and condition of the granules during such a cooking cycle. It will be noted that as swelling begins a viscosity rise is noted, which increases progressively as the granules become more swollen. Shortly after swelling begins, fragmentation also starts and continues at a more rapid rate as the viscosity increases. A peak viscosity is reached when the viscosity increase due to additional swelling is just balanced by the viscosity loss due to fragmentation. When the fragmentation viscosity loss exceeds the gain due to increased swelling, the paste loses viscosity and eventually levels out at a constant value which is dependent on several factors including temperature, time, and agitation.

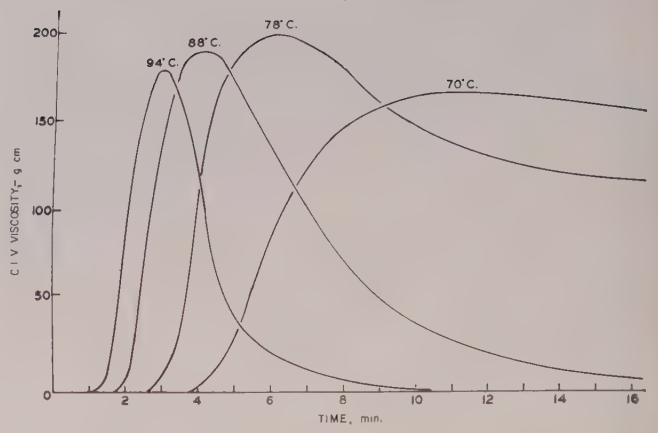

Fig. 2. Effect of temperature on viscosity development of 20% pastes of 90 fluidity thin-boiling starch

Figures represent maximum paste temperature.

The effect of shear on the paste viscosity is illustrated by the dotted line in Fig. 1, which was obtained by subjecting the paste at point *B* to the action of a Waring blendor for a period of one minute and then returning it to the viscometer beaker for the balance of the cooking cycle.

The effect of cooking temperature on the development and loss of paste viscosity during the cooking cycle is illustrated in Fig. 2 which show the Corn Industries viscometer curves for 20% pastes of a thin boiling starch cooked to the maximum temperatures shown. This particular, 90 fluidity starch is probably more

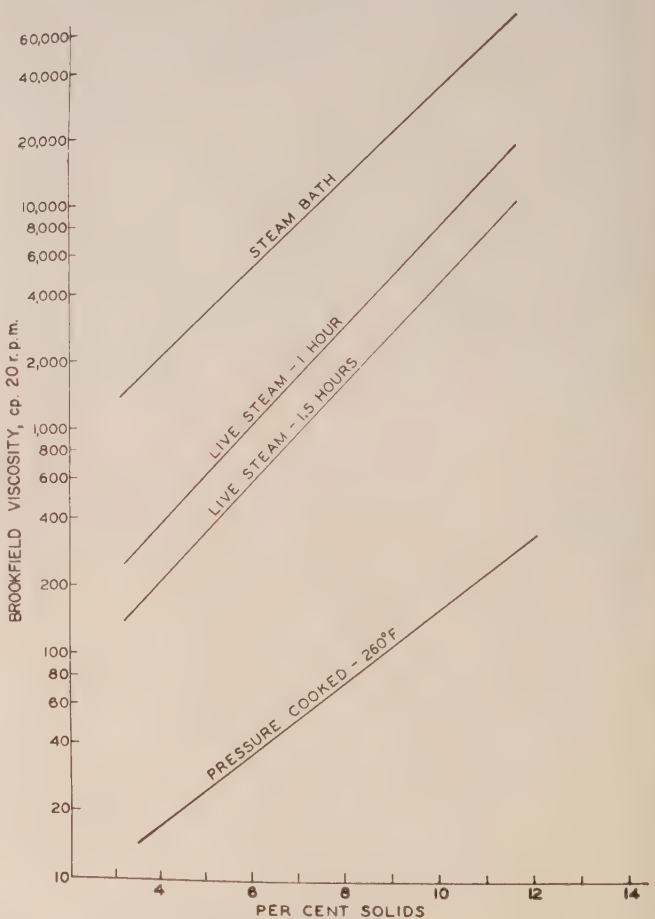

Fig. 3. Effect of different cooking procedures on viscosity at 150°F. of unmodified corn starch

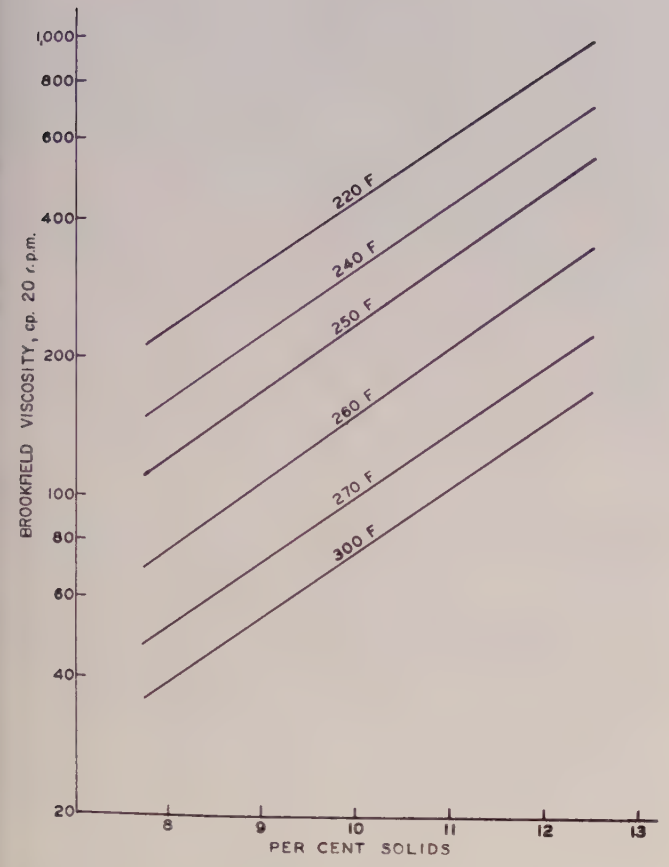

Fig. 4. Effect of various cooking temperatures on the viscosity at 150°F. of continuously pressure-cooked pastes of unmodified corn starch

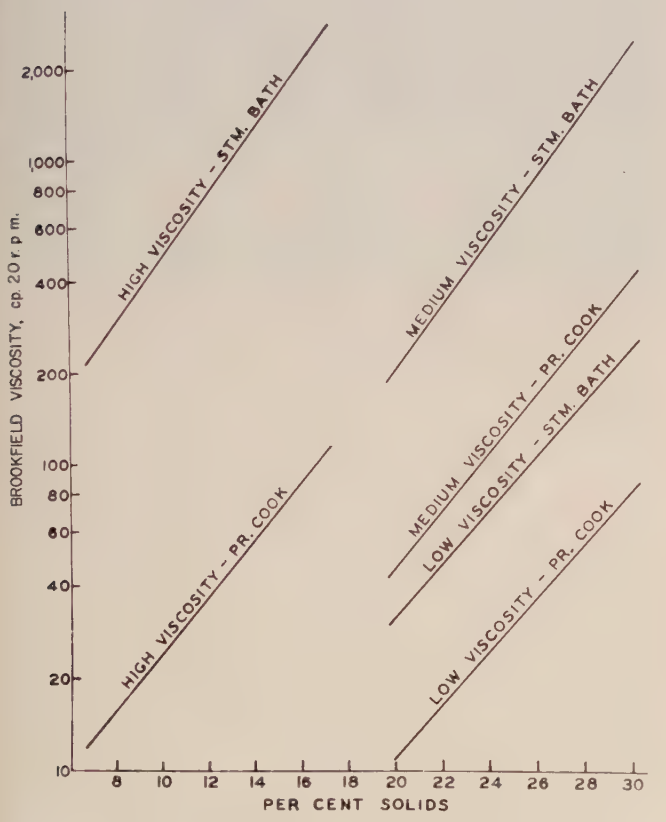

Fig. 5. Comparison of steam-bath cooked (195°F.—15 min.) and pressure-cooked (260°F.) pastes of several low-substituted corn-starch ethers

Viscosities measured at 150°F.

sensitive in this regard than many other starches, but the figure demonstrates, qualitatively at least, the effect of cooking temperature variations.

THE EFFECT OF PRESSURE COOKING

It becomes obvious that by using a technique which would impose rather drastic conditions of temperature and shear on a starch paste for even a short period of time the resulting paste might have unique properties. Indeed, it has been found to be easy to go from point *A* to point *C* in Fig. 1 by using a single quick pass through a continuous cooker operating at moderately increased temperatures and pressures.

Figure 3 further illustrates the swelling and disaggregating actions and consequent effect on viscosity of several commonly used starch cooking procedures. The steam bath cook is a common laboratory procedure and consists of heating a starch slurry on a steam bath

Table I. Effect of Pressure Cooking on Gel Strength

	—*Unmodified starch (pressure cook)*—				*Thin boiling starch (conventional cook)*
Max. temp., °F.	220	240	270	300	195
Paste[a] viscosity, cp. Brookfield, 20 r.p.m., No. 2 spindle					
190°F.	260	166	58	32	125
150°F.	410	238	64	52	300
Gel strength, g.-cm. 18 hr.	80	30	5	0	440

[a] Paste concentration = 10% D.S.

with periodic hand stirring to 195 to 200°F. and then holding at that temperature with occasional stirring for an additional 15 min. The live-steam cooks were similarly heated but were agitated mechanically and in addition had a jet of live steam blowing into the paste to contribute to the agitation and to compensate for evaporation losses. The pressure-cooked samples were processed at 260°F. and 30 p.s.i.g. pressure. All pastes were air cooled to 150°F. at which point Brookfield viscosities were determined. The paste concentrations are on the ovendried basis.

The relative effect on viscosity of continuously pressure-cooking unmodified cornstarch at several different temperatures is shown in Fig. 4. Here also the pastes were cooled to 150°F. prior to the viscosity determination.

Similar effects on the viscosity of pastes of modified and of starch derivatives are also obtained on cooking at elevated temperatures, although the viscosity decrease noted is usually less pronounced with the more depolymerized or thinner starches. Figure 5 shows the effect of cooking at 260°F. as compared with a conventional steam-bath cook (195°F.—15 min.) on the viscosity at 150°F. of a viscous starch ether, a medium viscosity starch ether frequently used for size press application and a thin starch ether produced for coating work.

Similar viscosity relationships are observed at temperatures both above and below 150°F. at which the above data were obtained. At temperatures of 120°F. and below, depending on the starch type used and on its concentration, the gelling tendency of the starch may make itself apparent in the observed viscosity, and the resulting viscosity curves frequently become erratic and questionable.

Even more pronounced than its effect on the viscosity of starch pastes is the effect of high-temperature cooking on the gelling properties of cooked starches. Table I illustrates the effect of various cooking temperatures on the gel strength of 10% unmodified cornstarch pastes after aging 18 hr. at 75°F. The figures reported for gel strength represent the force (expressed as gram-centimeters on the dynamometer of the Corn Industries viscometer) necessary to dislodge a metal disk (a U. S., one-cent piece) embedded 3.25 cm. below the surface of the gel. Also included for comparison are data on a conventionally cooked (195°F.—15 min.) thin boiling

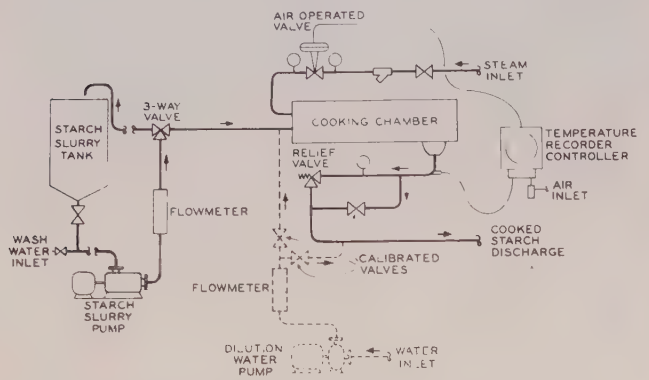

Fig. 6. Flow diagram of Thermal Equipment Corp. continuous pressure cooker for starch

starch selected to have a viscosity in the range of the other samples.

As the gelling tendency of a starch paste frequently has a bearing on the indicated viscosity of the paste on cooling or aging, pressure-cooked pastes usually show a lower viscosity increase on aging than conventionally prepared materials. This is also illustrated by the data in Table I.

CONTINUOUS PRESSURE-COOKING EQUIPMENT FOR STARCH

The patents and technical literature describes dozens of equipment layouts and techniques for cooking starches continuously at temperatures below the boiling point of water, and several manufacturers currently have such equipment available. On the other hand, relatively few cookers for continuously cooking starches under pressure have been devised. These pressure cookers fall into two general classes: (1) those using indirect steam heating, which usually incorporate a mechanical scraper for continuously removing the thickened, cooked, starch film from the heat-transfer surface; and (2) those which use some sort of device for directly mixing live steam with the raw starch slurry. Although the condensing steam tends to dilute the product, which is objectionable in some instances, all of our work has been with the latter type because of its greater simplicity and lower initial and operating costs.

When we first became interested in evaluating pressure-cooking processes and products we spent considerable time determining the merits and limitations of various steam-water mixers, jets, cooking chambers, etc. Most of these devices were surprisingly effective, but many performed satisfactorily only over rather narrow ranges of temperatures, flow-rates, or viscosities. We then cooperated with the Thermal Equipment Corp., Skokie, Ill., in adapting their continuous gum candy pressure cooker to the needs of the paper industry. The resulting unit has already gained considerable acceptance as an effective and flexible means for cooking starch for a variety of paper mill uses.

Basically the unit consists of a pump for forcing the starch slurry through the unit, a cooking chamber for mixing steam with the slurry, and a valve system for controlling the chamber pressure and temperature.

As shown in Fig. 6, a variable speed, positive displacement pump is used to transfer the starch slurry from the supply tank or slurry-recirculating loop through a flowmeter to the cooking chamber. In this chamber a series of nozzles ensure intimate contact of

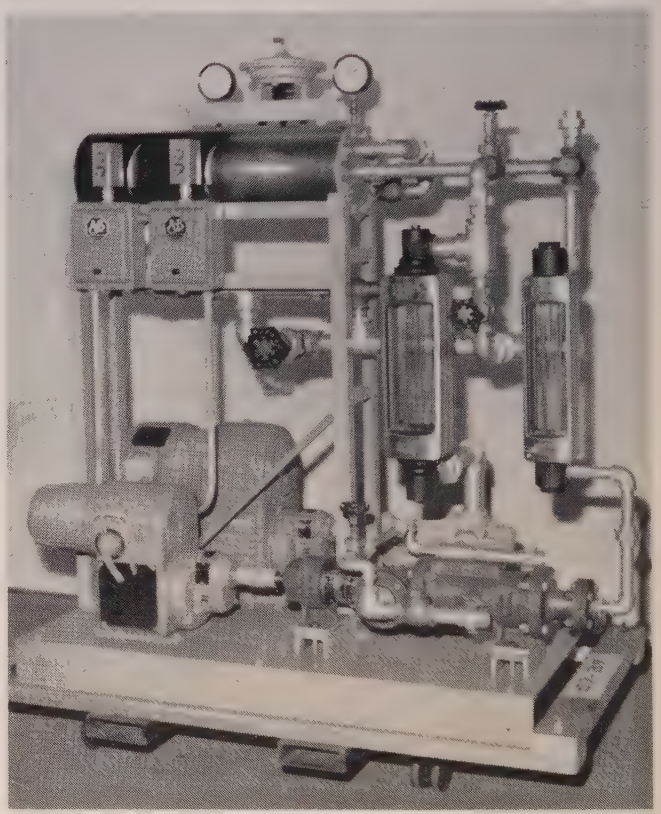

Fig. 7. Thermal Equipment Corp. continuous pressure cooker for starch. Model 20-A

the starch slurry and steam, and subject the cooked starch to a considerable degree of shear because of the violent turbulence. The steam flow is controlled by a valve actuated by a thermometer bulb in the cooker outlet line. Also in the cooker outlet line are valves for controlling the chamber pressure. Usually these consist of a manually operated valve and an adjustable spring-loaded, pressure-relief valve piped for parallel flow. Normally the valves are adjusted so that the bulk of the flow passes through the manually operated valve with just enough going through the relief valve to control the pressure. In other instances the manually operated valve only is used for flow and pressure control and the relief valve is used solely as a safety valve for pump protection. When used at elevated temperatures some sort of flash chamber on the outlet line is usually desirable.

In many instances the starch use concentration is

considerably lower than the maximum slurry concentration possible. For example, for a starch furnish addition it may be desirable to cook the starch at not over $^1/_3$ lb. per gal., or for a size-press application at $^1/_2$ to 1 lb. per gal. Both of these concentrations are far below the 3 or 4 lb. per gal. possible for slurries of most starches. To minimize the size of the necessary slurry tanks it is frequently desirable to prepare the starch slurry at relatively high concentrations and dilute it either before or after cooking. This is made possible in some of the units by the incorporation of continuous dilution facilities. These consist of a variable speed, positive displacement pump hooked to a water service line, and which delivers the desired diluent water through a flowmeter to either the starch-slurry line going to the cooking chamber or to the cooker-effluent line after the pressure-reducing valve. Some units are arranged with separate flowmeters on these two branches so that a starch may be accurately

Table II. Effect of Pressure Cooking on Coating Color Viscosity

	Conventional cook—195°F., 15 min.	*Pressure cook—250°F.*
Medium Viscosity Starch Ether		
Paste visc., 23% D.S., 135°F.[a]	1,180 cp.	520 cp.
Color visc., 40% D.S., 20% s/c, 80°F	14,000	9000
Low Viscosity Starch Ether		
Paste visc., 40% D.S., 190°F.[a]	240 cp.	120 cp.
Color visc., 62% D.S., 15% s/c, 80°F.	4,000	2700

[a] s/c = starch—clay.

and simultaneously diluted both before and after cooking. One model of such a two pump unit is shown in Fig. 7.

It is obvious that by the proper selection of original pump speeds and sizes for a given application, it is possible to prepare starches over a wide range of concentrations and flow rates with a single unit. Similarly, by simply adjusting the controls for chamber temperature and pressure the unit can be used for preparing starches at temperatures ranging from the 150 to 160°F., frequently used for furnish addition starches, all the way up to the 300°F. sometimes preferred for sizings and coating adhesives. By the proper selection of temperatures and pressures it is possible to approximate the same degree of gelatinization achieved by any batch-cooking process or to achieve the improved dispersion made possible by the use of elevated temperatures.

Because of the wide variation in the demands imposed on the unit by different users a number of modifications, more suitable to specific needs, are available from the manufacturer. In our work it soon became obvious that a single unit could not satisfy the needs of all potential users. Accordingly three basic sizes are now available which have capacities of roughly 10, 30, and 50 g.p.m. The capacity figures represent an approximate maximum total throughput and may be decreased somewhat at the higher operating temperatures and pressures. In each unit the pump sizes and speed ranges are selected to deliver the desired range of starch slurry and water flows necessary for the use in question. If the user does not desire or need the dilution feature, single pump units are available without it. For specific needs the units can be made with a special arrangement of components or base plate sizes, etc., to suit it for constricted or odd-shaped areas.

COOKER OPERATING PROCEDURES

When used to prepare starch for furnish addition the cooker is usually run continuously with the entire effluent being added to the stock stream. The starch-slurry pump speed is adjusted to give the starch quantity desired for the sheet being run. The flow of diluent water is adjusted to reduce the starch to a concentration that will cook and handle without difficulty.

For size press and calender size preparation also a continuous operation may be used, but it is usually more convenient to operate the cooker on an intermittent basis. The cooked size delivery rate is adjusted to slightly more than the maximum rate of size usage and the unit is automatically turned off-and-on by high- and low-level controls in a storage tank between the cooker and point of use. The starch may be slurried ahead in quantities sufficient for an hour, a shift or even a day's operation depending on the individual mill's conditions and equipment.

For coating color preparation, even though the cooker can operate continuously, the batch preparation procedure is still most generally used. While any desired quantity of starch may be slurried at one time, it is usually cooked in quantities sufficient for one batch of color with the cooker effluent being continuously added to and mixed with the previously prepared clay slip in a simple mixing tank. If preferred, the starch, pigment, and other additives may be slurried together and cooked as needed in a manner similar to that described above for size-press and calender-size preparation

ADVANTAGES OF CONTINUOUS PRESSURE COOKING

In recent years a tremendous interest has developed in automation and in the development of continuous processes to replace currently used batch operations. The advantages of such process revisions frequently include savings in labor and time, an increase in product uniformity and quality, and a degree of flexibility not possible with a batch operation. In those mills where conditions justify a continuous or automatic size or coating preparation system a continuous starch cooker should greatly facilitate such a layout, and certainly merits consideration.

In addition to the merits of the continuous feature of such a cooker the changed or unique properties which can be imparted to the starch pastes by high-temperature cooking appear advantageous in many paper mill applications.

The viscosity lowering noted in high-temperature-cooked starch pastes as compared with similar pastes cooked conventionally is carried over to the pigmented coating colors made with these pastes. This is illustrated in Table II.

In most coating formulations the color viscosity will be reduced by one quarter to one half as measured by a Brookfield viscometer when the starch adhesive is pressure-cooked as compared with a conventional cook of the same adhesive. There is, of course, a considerable variation in the reduction, depending on the starch

Table III. Effect of Pressure Cooking on Clay Dispersion

	Control	*Pressure cooked*
% on 325 mesh	0.0015	0.0015
% over 15 μ	0.023	0.018
% under 2 μ	83.2	85.0

type and the formulation used. The viscosity reduction is usually greater with the lower-modified or more viscous starches, and in those coating formulations where the starch contributes a relatively larger proportion of the total viscosity.

In those instances where coating color viscosity requirements are being adequately met by the conventional preparation of a particular starch, the use of high-temperature cooking procedure frequently requires the use of a more viscous grade of starch because of this viscosity lowering effect.

In other instances where viscosity requirements cannot be met by cooking the currently available thinner starches conventionally, the use of a pressure cooker sometimes makes possible the use of these same products. The ever increasing demand for thinner starches which will permit the use of higher color solids can frequently be at least partially satisfied by pressure-cooking the currently used materials.

For many years some paper mills have cooked their starch adhesive or even enzyme-converted starch in the presence of the clay or other pigment used in their coating colors. Improved results were claimed for such a procedure owing to the more intimate starch-clay mixture obtained. It seems quite probable that the presence of the clay during the cooking operation increases the shear imposed on the swollen starch granules by the normal tank agitation and tends to break up or disperse these fragile starch balloons. The resulting small starch fragments have more opportunity to contact the pigment surfaces and are more effective as an adhesive. An improved coating-pick results or a reduced starch/clay ratio is made possible.

Pressure cooking of the starch adhesive has the same general effect, only probably to a somewhat greater degree. The fully hydrated starch granules are more completely fragmented or dispersed in the cooking process, usually with an apparent increase in their adhesive effectiveness resulting. In most instances a wax-pick increase of one or two points is observed for a given formulation when pressure cooking replaces conventional starch preparation.

In most cases the cooked starch is mixed with the pigment suspension while the paste is still hot so its tendency to gel is of little consequence as such. Where the cooked starch is aged or cooled prior to blending with the pigment, the lowered gelling tendency of the pressure-cooked starches could make their use advantageous. Similarly, this feature could also be of importance for certain surface sizing or adhesive applications, especially those using starch grades or concentrations which result in a viscous paste and in which the gelling tendency on aging could be of critical importance.

In addition to the considerable effect of pressure cooking on the viscosity, gelling tendency, and degree of hydration of the starch portion of a starch-pigment paper coating color, there is also evidence to indicate the pigment too will be affected by such treatment. Some mills have reportedly found that pressure cooking a starch-clay coating color improves the clay dispersion to the extent that the previously necessary kneaders or high-shear dispersing equipment could be used to a lesser extent or even dispensed with.

In our preliminary laboratory work we could see no significant difference in viscosity or flow properties of colors prepared with pigments which were pressure cooked, either alone or with starch, as compared with similar colors where the clay was slurried conventionally and mixed with a pressure-cooked starch.

To further investigate the effect of pressure cooking on dispersion a predispersed coating clay was slurried in a 70% concentration with 0.2% (on clay) added Quadrafos for 3 hr. using a laboratory Lightnin' mixer. Part of this slip was continuously pressure cooked at 300°F. and 55 p.s.i.g. The resulting slip contained 62.5% solids to which the uncooked portion of the slip was also adjusted. Both portions were then checked for particle size, as shown in Table III.

The data indicate that pressure cooking does tend to improve the dispersion of clay. Whether the improvement is significant for a given application would probably depend on a number of factors including: the degree of dispersion necessary for the application in question, the dispersing properties of the clay or other pigment used, the other pigment dispersing facilities available, and the availability and cost of steam and electric power. Cooking the pigment portion of the color may also make necessary the use of cooling facilities to lower the temperature of the finished color to a usable range. In some instances, of course, diluent water could be used for any necessary temperature lowering.

Preliminary data indicate that the reaction of starch with other materials such as insolubilizing resins is frequently changed by cooking at elevated temperatures and pressures. For example, oven-cured drawdowns of a conventional starch-clay coating color to which a melamine-formaldehyde resin had been added were found to have negligible water resistance until the pH of the applied color was lowered to the 5.0 to 5.5 range. On the other hand, a similar formulation in which the resin was pressure-cooked with the starch portion prior to addition to the clay was found to develop significant wet-rub resistance even at pH's of 7.0 and above. Much work remains to be done in evaluating this approach to starch insolubilization as well as the effect of pressure cooking on other starch reactions.

Similarly, it has been indicated in preliminary work that the effect of soap on starch-containing sizes and coating colors may be considerably changed when the starch or starch-soap mixture is pressure cooked. The inhibiting effect of soap on the starch gelatinization can be completely overcome by pressure cooking, and preliminary indications are that the viscosity effect of soap additions on starch pastes and colors are considerably reduced by such cooking. Here also much work remains to be done in investigating the possible advantageous use of the pressure cooker with such formulations.

Received June 6, 1960. Presented at the 11th Coating Conference of the Technical Association of the Pulp and Paper Industry, held in Chicago, Ill., May 23–25, 1960.

The authors would like to acknowledge the assistance of Dr. Nathan Millman of the Huber Co. in whose laboratory the clay particle size determinations were made.

ASSOCIATION NEWS AND EVENTS

National Conferences

1961

46th Annual Meeting, Feb. 20–23, 1961, Commodore Hotel, New York, N. Y.

Twelfth Coating Conference, May 8–10, 1961, Statler-Hilton Hotel, Buffalo, N. Y.

ISA-TAPPI Symposium on Instrumentation in the Pulp and Paper Industry, May 10–12, 1961, Northland Hotel, Greenbay, Wis.

Lignin Symposium, Aug. 14–16, 1961, Edgewater Beach Hotel, Chicago, Ill.

Twelfth Testing Conference, Aug. 15–18, 1961, Queen Elizabeth Hotel, Montreal, Que.

Eleventh Corrugated Containers Conference, Sept. 11–13, 1961, St. Francis Hotel, San Francisco, Calif.

Fourth International Mechanical Pulping Conference, Sept. 19–21, 1961, Edgewater Beach Hotel, Chicago, Ill.

6th Deinking Conference, Oct. 4–6, 1961, Hotel Harris, Kalamazoo, Mich.

Sixteenth Plastics-Paper Conference, Oct. 9–11, 1961, French Lick Shearaton Hotel, French Lick, Ind.

Sixteenth Engineering Conference, Oct. 15–19, 1961, Shoreham Hotel, Washington, D. C.

Fifteenth Alkaline Pulping Conference, Nov. 1–3, 1961, Rice Hotel, Houston, Tex.

10th Statistics Course, June 17–30, Queens Univ., Kingston, Ontario.

1962

47th Annual Meeting, Feb. 18–22, 1962, Commodore Hotel, New York, N. Y.

Thirteenth Coating Conference, May 14–16, 1962, Netherland-Hilton Hotel, Cincinnati, Ohio.

Thirteenth Testing Conference, Sept. 18–20, 1962, Benjamin Franklin Hotel, Philadelphia, Pa.

Seventeenth Engineering Conference, Oct. 14–19, 1962, Queen Elizabeth Hotel, Montreal, Que.

Twelfth Corrugated Containers Conference, Oct. 23–26, 1962, Statler-Hilton Hotel, Boston, Mass.

Sixteenth Alkaline Pulping Conference, Oct. 31, Nov. 1–2, DeSoto Hotel, 1962, Savannah, Ga.

1963

Fourteenth Coating Conference, May 19–22, 1963, French Lick Sheraton Hotel, French Lick, Ind.

Thirteenth Corrugated Containers Conference, Oct. 22–25, 1963, Statler-Hilton Hotel, Detroit, Mich.

Eighteenth Engineering Conference, Oct. 28–31, 1963, Netherland Hilton Hotel, Cincinnati, Ohio.

Other Associations

The German Association, Verein der Zellstoff und Papier Chemiker und Ingenieure, will hold its annual meeting in Baden-Baden, June 27–30, 1961.

The 4th DRUPA-International Fair Print and Paper will be held at Dusseldorf, May 5–18, 1962.

The Eleventh National Chemical Exposition, sponsored by the Chicago Section American Chemical Society, International Amphitheatre, Chicago, Ill., Sept. 5–8, 1961.

The Thirteenth International Chemical Engineering Exposition and Congress, Frankfurt am Main, Germany, June 9–17, 1961.

The Twenty-fourth Annual Short Course for Superintendents and Operators of Water and Sewage Systems will be held at Louisiana State University on March 15–17, 1961.

The Ninth Annual Short Course in Fundamentals of Occupational Safety will be held at Louisiana State University on Aug. 14–17, 1961.

Inter-Society Color Council 30th Annual Meeting

The 30th Annual Meeting of the Inter-Society Color Council will be held at the Sheraton Hotel, Rochester, N. Y., on Monday, Tuesday, and Wednesday, April 10–12, 1961.

On Monday, April 10, meetings of the color problems subcommittees will be held.

The annual business meeting will be on Tuesday morning, April 11. During Tuesday afternoon and Wednesday morning a symposium will be held under the general title of "Color in Photography and Television." The banquet will be held on Tuesday evening.

For further information, write: Ralph M. Evans, secretary, Inter-Society Color Council, Color Technology Division, Building 65, Eastman Kodak Co., Rochester 4, N. Y.

Eighteenth International Congress of Pure and Applied Chemistry

Fifteen invited papers by scientists from seven different countries, will be given at the wood chemistry symposium to be held in conjunction with the 18th International Congress of Pure and Applied Chemistry at Montreal from August 6 to August 12 inclusive.

Lecturers and their subjects will be:

Prof. T. Enkvist, Helsingfors, Finland—"New Aspects on Lignin Reactions in Kraft Pulping"
Prof. K. Freudenberg, Heidelberg, Germany—"Biogenesis and Constitution of Lignin"
Dr. D. A. I. Goring, Montreal, Canada—"The Physical Chemistry of Lignins"
Dr. J. K. Hamilton, Shelton, Wash., U. S. A.—"The Behavior of Wood Carbohydrates in Technical Pulping Processes"
Dr. J. J. Hermans, Syracuse, U. S. A.—"Chemical Mechanisms in the Grafting of Cellulose"
Prof. E. L. Hirst, Edinburgh, Scotland—"The Chemical Structure of the Hemicelluloses"
Prof. J. K. N. Jones, Kingston, Canada—"Biogenesis of Carbohydrates in Woods"
Prof. Bengt Lindberg, Stockholm, Sweden—"New Methods for Isolating Hemicelluloses"
Dr. J. Mann, Manchester, England—"Modern Techniques for Estimating the Crystallinity of Cellulose"
Dr. R. H. Marchessault, Marcus Hook, Pa., U. S. A.—"Applications of Infrared Spectroscopy to the Study of Cellulose and Wood Polysaccharides"
Dr. Hans Meier, Stockholm, Sweden—"Chemical and Morphological Aspects of the Fine Structure of Wood"
Prof. A. H. Nissan, Troy, U. S. A.—"Cellulose as a Visco-Elastic Polymer"
Prof. Kyosti Sarkanen, Syracuse, U. S. A.—"The Chemistry of Delignification in Pulp Bleaching"
Prof. Lennart G. Stockman, Stockholm, Sweden—"Recent Developments and Present Trends in Sulphite Pulping"
Dr. Kyle Ward, Jr., Appleton, Wis., U. S. A.—"Fractional Extraction of Hemicelluloses and Their Properties"

The symposium was organized by the Pulp, Paper and Board Committee of the International Union of Pure and Applied Chemistry. Chairman of this committee is Dr.

Wilfred Gallay, director of research for the E. B. Eddy Co., Hull, Quebec. The Eighteenth Congress will be the largest scientific conference ever to be held in Canada and is expected to attract delegates from more than 40 countries.

Forest Biology Conference

The TAPPI Forest Biology Conference was held on Aug. 24–27, 1960, at the New Washington Hotel in Seattle, Wash. This conference was sponsored by the TAPPI Forest Biology Committee, D. D. Stevenson, Buckeye Cellulose Corp., Foley, Fla., chairman.

This first Forest Biology Conference was attended by 65 people from ten States, Canada, Australia, Scotland, and the Philippine Islands.

An excellent program was prepared under the direction of J. W. Duffield, Col. W. B. Greeley Forest Nursery, Nisqually, Wash. The papers, published in other issues of *Tappi*, stimulated much discussion by those present.

J. R. Lientz, Union Bag-Camp Paper Corp., Savannah, Ga., president of TAPPI presented an introduction to the conference. He pointed out "the conference theme 'Better Fibers from Better Tree Through Forest Biology' highlights a need which must be fulfilled if the pulp and paper industry is to continue to grow and flourish." He continued by describing how TAPPI, through the Forest Biology Committee, is attempting to assist in the fulfillment of the need by coordinating the thinking between forest biologists and pulp and papermakers.

Principal addresses were presented by J. L. McCarthy, Univ. of Washington, Seattle, Wash., and by L. R. Thiesmeyer, Pulp and Paper Research Inst. of Canada, Montreal, Que., Canada.

The technical program which followed is shown below.

THURSDAY, AUG. 25, 1960

First Technical Session—"Evaluation of Wood Properties"

Moderator: R. W. Wellwood, Univ. of British Columbia, Vancouver, B. C.

1. "Some Mechanical Properties of Wood Fibers in Tension," by B. A. Jayne, Washington State University, Pullman, Wash.

Conference Committee: R. J. Seidl, Simpson Timber Co., Seattle, Wash., Chairman; J. W. Duffield, W. B. Greeley Forest Nursery, Nisqually, Wash., Tech. Program Chairman; J. P. Van Buijtenen, The Institute of Paper Chemistry, Appleton, Wis., Tech. Program Committee; B. A. Jayne, Washington State Univ., Institute of Technology, Pullman, Wash., Program Committee; R. F. Callahan, Forest Service, U. S. Dept. of Agriculture, Spokane, Wash., Local Arrangements Chairman; R. F. Sultze, Simpson Timber Co., Seattle, Wash., Local Arrangements Committee

R. J. Seidl, Simpson Timber Co., Seattle, Wash.; D. D. Stevenson, Buckeye Cellulose Co., Foley, Fla.; J. R. Lientz, Union Bag-Camp Paper Corp., Savannah, Ga.; L. R. Thiesmeyer, PPRIC, Montreal, Canada

2. "Pulping Southern Pine Increment Cores by Means of a Microkraft Procedure," by J. P. van Buijtenen, P. N. Joranson, The Institute of Paper Chemistry, Appleton, Wis., and D. J. MacLaurin, Island Paper Mills, New Westminster, B. C.
3. "Variation and Periodicity of Summerwood Formation in Douglas-fir," by R. W. Kennedy, University of British Columbia, Vancouver, B. C.
4. "A Biological Basis for Sampling in Studies of Wood Properties," by S. D. Richardson, University of Aberdeen, Scotland.

Second Technical Session

Panel Discussion: "Can Biological Improvement of Fiber Properties Keep Pace with Technological Advances?"

Introduction: J. W. Duffield, Col. W. B. Freeley Forest Nursery, Nisqually, Wash.; conference program chairman.

Panel Members:

Moderator: H. E. Dadswell, Division of Forest Products, C.S.I.R.O., Melbourne, Australia

Paper Technologists: W. A. Chilson, Forest Products Laboratory, U. S. Forest Service, Madison, Wis.; P. J. Frost Crown Zellerbach Corp., Camas, Wash.

Forest, Biologists: S. S. Pauley, University of Minnesota

Subcommittee on Bibliography: F. W. Wangaard, J. P. Van Buijtenen, P. Larson, E. Ellis, J. W. Duffield

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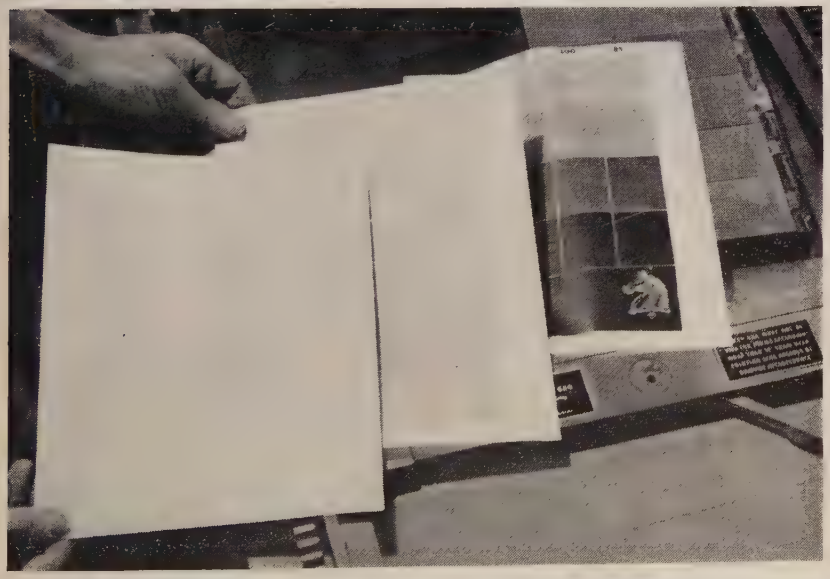

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First Session: R. W. Wellwood, Univ. of B. C., Vancouver, B. C.; B. A. Jayne, Washington State Univ., Pullman, Wash.; J. P. Van Buijtenen, The Institute of Paper Chemistry, Appleton, Wis.; R. W. Kennedy, Univ. of B. C., Vancouver, B. C., Canada

St. Paul, Minn.; P. N. Joranson, The Institute of Paper Chemistry, Appleton, Wis.

FRIDAY, AUG. 26, 1960

Third Technical Session—"Variations in Wood Properties"

Moderator: M. D. McKimmy, Oregon State College, Corvallis, Ore.

5. "Tree-to-Tree Variations and Gross Heritability of Wood Characteristics of *Pinus Radiata,*" by H. E. Dadswell and J. W. P. Nicholls, Division of Forest Products, C.S.I.R.O., Melbourne, Australia; and J. M. Fielding and A. G. Brown, Forestry and Timber Bureau, Canberra, Australia.
6. "Anatomical Responses of Loblolly Pine to Soil Water Deficiencies," by C. M. Smith, Forest Products Laboratory, U. S. Forest Service, Madison, Wis.
7. "Effect of Fertilizer on Wood Properties of Loblolly Pine," by B. J. Zobel, F. Goggans, T. E. Maki, and F. Hensen, North Carolina State College, Raleigh, N. C.
8. "Variation in Specific Gravity and Fiber Length in Wood of Yellow Poplar," by E. Thorbjornsen, University of Tennessee, Knoxville, Tenn.

Fourth Technical Session—"Influence of Wood and Fiber Properties on Pulp and Paper Characteristics"

Moderator: J. M. McEwen, Weyerhaeuser Co., Everett, Wash.

9. "Pulp and Paper Processes and Their Characteristic Differences," by H. W. Bialkowsky, Weyerhaeuser Co., Longview, Wash.
10. "Pulpwood Properties—Response of Processing and Paper Quality to Their Variation," by E. F. Thode, The Institute of Paper Chemistry, Appleton, Wis.
11. "Relationships between Hardwood Fiber Characteristics and Pulp Sheet Properties," by F. N. Tamolang, The School of Forestry, Yale University, New Haven, Conn.

On Saturday, Aug. 27, 1960, the conference attendents participated in a most interesting field trip, with visits to the Col. W. B. Greeley Forest Nursery, Nisqually, Wash., and to Perpetual Forests, Inc., Seed Orchard, Grand Mound, Wash.

R. J. Seidl, Simpson Timber Co., Seattle, Wash., was conference chairman. The technical program committee consisted of J. W. Duffield, chairman; B. J. Zobel, School of Forestry, North Carolina State College, Raleigh, N. C.; J. P. van Buijtenen, The Institute of Paper Chemistry, Appleton, Wis.; and B. A. Jayne, Washington State University, Institute of Technology, Pullman, Wash. Local arrangements and the field trip were under the direction of R. F. Callaham, Forest Service, U. S. Dept of Agriculture, Spokane, Wash., who was assisted by R. F. Sultze, Simpson Timber Co., Seattle, Wash.

Remarks by J. R. Lientz, President of TAPPI

It is most significant and highly fitting that the TAPPI Forest Biology Conference is being held in Seattle at the time that American foresters are welcoming their colleagues from all over the world to the Fifth World Forestry Congress. The opportunity to consider the necessity for improving the basic raw material of our huge pulp and paper industry is in itself most stimulating. To be able to relate our own particular problems to those of all forest product industries throughout the world is an experience which will be revealing —even exciting.

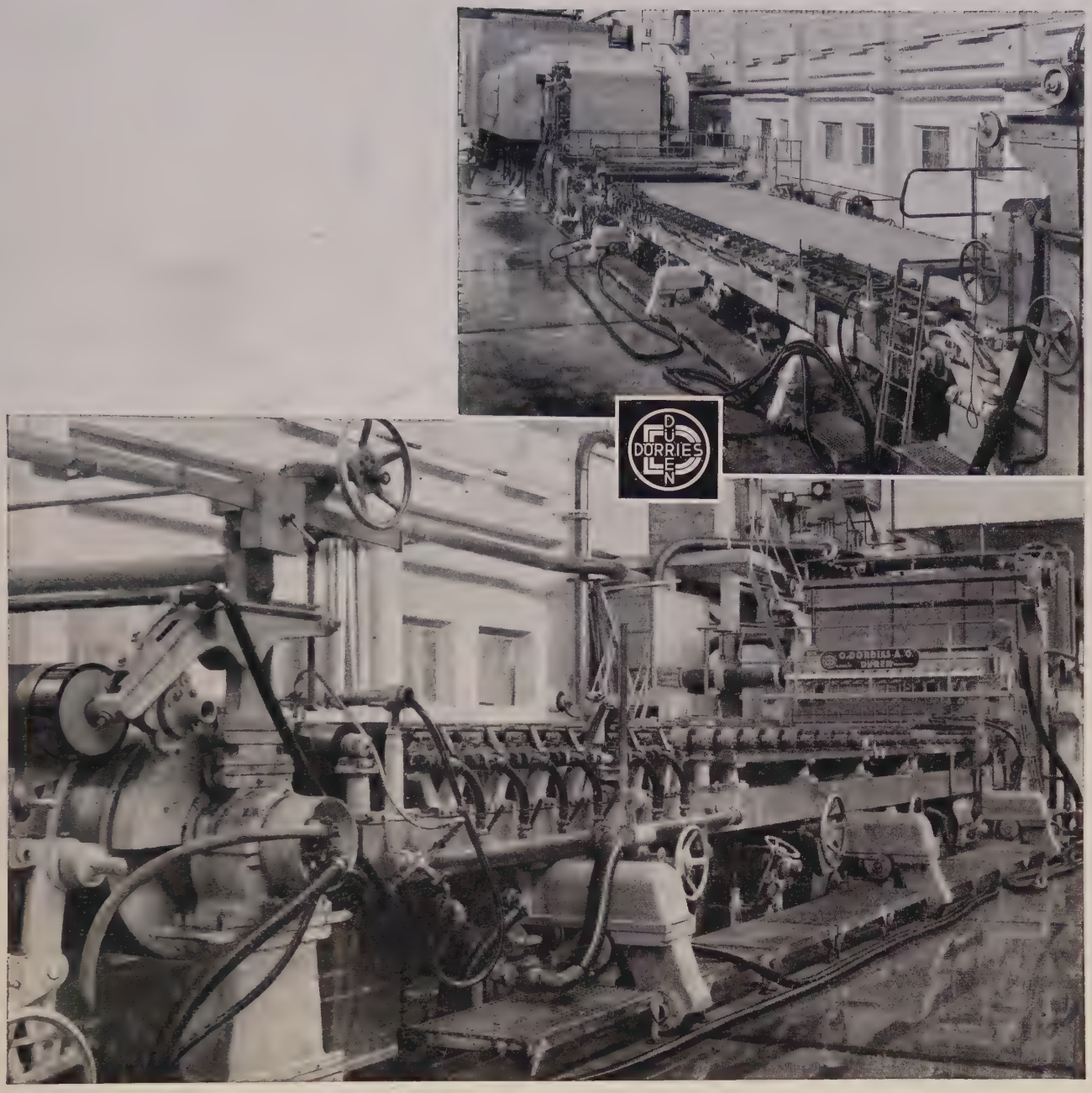
The conference theme, "Better Fibers from Better Trees Through Forest Biology," highlights a need which must be fulfilled if the pulp and paper industry is to continue to grow and fluorish. Unquestionably, the consciousness of competitive forces in our industry has been paramount in stimulating and accelerating the activities of geneticists and other interested in forest tree improvement.

TAPPI's function has been to insure the interchange of information between those who can define the fundamental characteristics of the fibers required and those who can translate these needs into an eventual forest improvement which ultimately will result in the production of raw materials fulfilling these requirements. The teamwork developed between foresters and pulp and papermakers as a result of this committee program will go far toward guaranteeing future progress and expansion of our industry.

The scope of the assignment of the Forest Biology Committee permits it to think in terms of forest genetics and forest tree improvements as related to wood as a raw material for our particular industry. At the same time, this general program permits us to take the lead in pure research which ultimately and inevitably will benefit all forest product consumers. Eventually, we are sure that thoughtful consideration by this group will be given to every phase of forestry affecting wood quality, such as tree spacing, growth rates, species, fertilization, rotation age (management technique of control) and other factors.

Future meetings of this group may well consider the same theme as this conference, with such added qualifications as "At a cost we can afford" or "At the time we need them."

Second Session: J. W. Duffield, Col. W. B. Greeley Forest Nursery, Nisqually, Wash.; W. A. Chilson, Forest Products Laboratory, Madison, Wis.; P. J. Frost, Crown Zellerbach Corp., Camas, Wash.; S. S. Pauley, Univ. of Minnesota, St. Paul, Minn.; P. N. Joranson, The Institute of Paper Chemistry, Appleton, Wis.



From planning to start

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Obviously, of course, "better fibers" today could enhance our position as an industry.

Coordination of thinking between forest biologists and pulp and papermakers is fundamental to the success of this committee. Cooperatively, we must develop a program to improve wood quality genetically and silviculturally. Many of us are well aware of the valuable work done by genetics in improving farm crops and livestock. We recognize, in a broad sense, the potential value of improvement in fiber strength and chemical composition. However, we need more clearly to define "better fibers." Ultimately, our definition of "better fibers" or "better trees" should be the same.

The question of what constitutes a "better fiber," or for that matter, a "better tree," is still to be answered. Probably there is no such thing as "*The* Better Fiber." So—development of new and improved strains of species furnishing commercially available pulpwood must be patterned to specific needs—or, perhaps, first to broad improvements that may encompass those needs.

In many cases, the end use to which a fiber is subjected clearly suggests the requirements of different physical and chemical characteristics. For instance:

1. Unbleached paper pulps seem to require high fiber strength and inherent bonding strength. These qualities may be dependent upon moderate amounts of hemicellulose properly distributed in the fiber wall.
2. Pulps for towels or tissues require fiber softness, absorbency, and bleachability. Perhaps a low lignin content within the cell wall would be important here.
3. Glassine and greaseproof paper pulps apparently required high hemicellulose contents.
4. Groundwood pulps need low rosin contents.
5. Dissolving pulps need high alpha-cellulose and a minimum of hemicellulose.

Obviously, the characteristics associated with these various pulp types are vague, incomplete—perhaps incorrect. This typifies our lack of knowledge of the type of fibers actually needed. We just don't know! In fact, we are not too familiar with the structure of the fibers we are now using.

This lack of knowledge has inspired rather than discouraged us. Immediate work is being directed toward the broad development of better hardwood and softwood species through improvement of fiber volume and fiber length. Significant progress is being made in these areas of forest

***Third Session:** J. H. G. Smith, Univ. of B. C., Vancouver, B. C.; J. M. Fielding, Forestry and Timber Bureau, Canberra, Australia; D. M. Smith, Forest Products Lab., U. S. Forest Service, Madison, Wis.; B. J. Zobel, North Carolina State College, Raleigh, N. C.; E. Thorbjornsen, Univ. of Tennessee, Knoxville, Tenn.*

***Fourth Session:** J. M. McEwen, Weyerhaeuser Co., Everett, Wash.; E. F. Thode, The Institute of Paper Chemistry, Appleton, Wis.; F. N. Tamolang, School of Forestry, Yale Univ., New Haven, Conn.; F. F. Wangaard, School of Forestry, Yale Univ., New Haven, Conn.*

biology, and successful efforts of people in this very group are already well known.

It is vitally important that close liasion and understanding be maintained between the woods and the mill. TAPPI is strongly committed to enhancing the technical progress of our entire industry, and this conference can serve as another outstanding example of industry teamwork in a field that offers many challenges, and where mutual opportunities are unlimited.

Panel Discussion: "Can Biological Improvement of Fiber Properties Keep Pace with Technological Advances?"

After the introduction of Dr. Duffield, the moderator of the panel, Dr. Dadswell, set the stage for the discussion by summarizing the important wood properties relative to their influence on pulp properties as: (a) fiber length and width, (b) fiber wall thickness, (c) micellar angle, and (d) the relative proportion of cellulose, hemicellulose, lignin, and extractives.

Fiber length has a definite influence on the tearing resistance of paper. This was proved inclusively by cutting pulp fibers to varying lengths and preparing hard sheets for strength evaluation. Fiber length is also related, through less directly, to other strength properties. Increasing fiber wall thickness increases the tearing resistance of paper but decreases other strength properties. If a constant length is maintained, the fiber length:fiber width ratio makes little difference.

An increase in the hemicellulose content of pulp is generally beneficial. Lignin does not contribute to strength development, although it is not necessarily a disadvantage in certain grades of pulp. Extractives are generally troublesome, and the amount in the wood should be reduced as much as possible.

The moderator then introduced the first panel member to speak on the side of the forest geneticists, Dr. Scott Pauley. Dr. Pauley first interpreted the question to be discussed: "Can forest biology keep pace with technological advances?" He felt that, taking the question at face value, the answer should be "no"; but that the forest biologists certainly can make valuable contributions in increasing the productivity of our forest and in improving pulp quality. He felt that pulp and paper technologists and forest biologists could and should work hand in hand to achieve these objectives. Dr. Pauley then developed the general background of forest genetics, sketching the meaning and importance of wood anatomy, evolution, natural selection, and variation. He

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then applied these genetic principles to environmental and genetic variation and discussed how these could be utilized in a practical manner. He emphasized that the greater the number of wood quality improvements desired, the greater the number of compromises that would be necessary.

The moderator then introduced Mr. Frost speaking on the side of the paper technologists. He felt that uniformity of the raw material was the most important requirement from the technological point of view. In addition, the ideal tree should be rapidly growing, have a high density, little taper, high resistance against dry rot and other diseases, both in the forest and the wood yard, and should be easily penetrated by pulping liquors. Where pulpwood is grown at short rotations, he felt the forest biologists might possibly be able to keep up with shifts in product demand, but at long rotations, it would be virtually impossible.

The moderator then returned the floor to the defenders of the viewpoint of forest biology. Dr. Joranson stressed that the success of genetic improvement of pulpwood depends on knowledge of the future requirements and the centainty that wood will remain the main source of raw material. He predicted increased competition within the industry and between industries and a general increase in the intensity of forest land use. He felt that these challenges could be met by the application of genetics, forest fertilization, irrigation, and possibly by modification of the weather.

Giving some examples of how forest genetics can help paper technology, Dr. Joranson indicated that at this moment highly uniform experimental materials are available which form a much better material for technological experimentation than logs randomly selected from the woodyard. Another point he made was that only forest biology can increase fiber length or increase cellulose content. The pulp and paper technologists invariably reduce fiber length and destroy some cellulose in processing wood to paper. Dr. Joranson then discussed some of the results obtained at The Institute of Paper Chemistry, indicating that certain pulp properties are indeed subject to genetic control.

After a short intermission, Warren Chilson, speaking for the paper technologists, outlined their main problem: to make a uniform product out of a variable raw material at as high a speed as possible. Since absolute uniformity cannot be obtained, it is maintained within specified limits by means of bleading various pulps. In this, economics play a major role. He stated that long fibers, short fibers, thin fibers, and thick fibers are presently available to the pulp and paper industry. Summing up his considerations, he concluded that the main objectives should be uniformity and yield.

The moderator then opened the floor for general discussion. Mr. Besley commented on the contrast between the uniformity desired by the paper technologists and the emphasis on variation as a source of improvement by Dr. Pauley. He wondered whether uniformity could not be obtained equally well by mixing and by adequate knowledge of the sources of raw material available. Dr. Clark remarked that too much emphasis was placed on individual fibers. In his opinion, the following properties were important: weighted average fiber length, fineness of the fiber, intrinsic fiber strength, the cohesiveness of the fiber, the wet fiber flexibility, and the ability of sheet strength to develop rapidly on beating. Dr. Swan regretted the complexity of the improvement goals and felt it might be better to concentrate on a few basic objectives such as the production of healthy vigorous trees with perhaps longer fibers, and a higher density. Mr. Frost pointed out that his company made a great number of paper products from a variety of pulpwood species. He remarked that tear, although stressed very heavily, was not always important and that in some cases, for instance, smoothness was just as important. In some products, such as multiwall bags, an entirely different property might be important such as the total work energy absorbed. Dr. Thode was worried that the paper technologists might be specifying too much and that, at present, only a few properties should be stressed which are generally valuable. Dr. Duffield suggested that several kinds of fibers might be developed which could be used and mixed as needed. Dr. Zobel stressed that, in the south, the use of improved trees in the pulp and paper industry was an established fact and that the utmost effort should be made to continue this and to extend tree improvement to other regions as well. He emphasized that tree breeding is here to stay and should be recognized as a valuable aid to the pulp and paper industry. Mr. Wagle commented on the presence of environmental and genetic variability and wondered how much could be achieved by silvicultural control. Mr. Grantham suggested that the requirements for the pulpwood industry and for the lumber industry are rather different; that in Douglas-fir for instance, a low percentage of late wood is desirable for pulpwood, but that a high percentage is desirable in lumber. Dr. Boutwell supported Dr. Zobel in his plea for intensive tree improvement in the south where millions and millions of seedlings will be raised in the very near future. Mr. Frost wondered whether it would be possible to get rid of the antipulping compounds in Douglas-fir by means of genetic improvement and so make it possible to produce a sulfite pulp from this wood. Dr. Joranson remarked that the situation was not complex in all cases, that there are quite a number of large mills that make large amounts of pulp from only one or two species and concentrate on a very small number of products. Mr. Sultze wondered whether it would be possible to reduce the lignin content of wood or change its chemical composition somehow to facilitate pulping and bleaching. Mr. Clark commented that we do not want, primarily, wood of a higher density. What we want is the most cellulose production per acre. For pulpwood, a low density is more desirable. This, of course, does not hold true for lumber.

The panel moderator, Dr. Dadswell, then summed up the various comments and cautioned against trying to achieve too many goals at once. He concluded that the topic still had not been adequately covered, but that to him the consensus of opinion appeared to be affirmative with regard to the question under discussion.

Banquet: J. R. Lientz, Union Bag-Camp Paper Corp., Savannah, Ga., President of TAPPI; J. M. McEwen, Weyerhaeuser Co., Everett, Wash.; L. R. Thiesmeyer, Pulp and Paper Research Institute of Canada, Montreal, Que., Canada; A. J. Winchester, TAPPI, New York, N. Y.; D. D. Stevenson, Buckeye Cellulose Corp., Foley, Fla.; R. J. Seidl, Simpson Timber Co., Seattle, Wash.

Tenth Corrugated Containers Conference

The Tenth Corrugated Containers Conference was held on Oct. 10–13, 1960, at the Royal York Hotel in Toronto,

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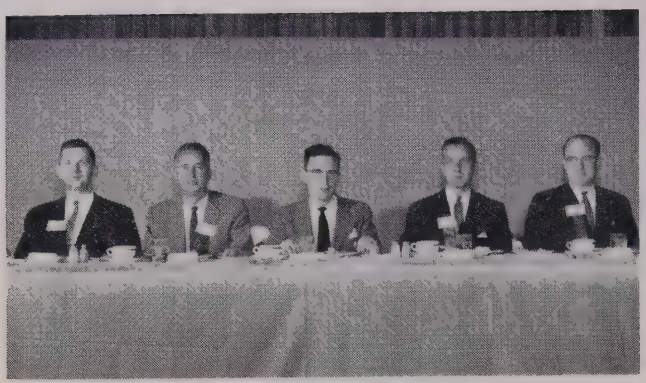

R. A. Joss, CPPA, Montreal, Que.; H. S. Godwin, Bathurst Containers, Ltd., Toronto, Ont.; D. M. Farrell, Bathurst Containers, Ltd., Montreal, Que.; W. G. James, St. Lawrence Corp., Ltd., Montreal, Que.; W. J. Hurrell, Hinde & Dauch, Ltd., Etobicoke, Ont.

A. J. Winchester, TAPPI, New York, N. Y.; R. H. McGee, Bathurst Power & Paper Co., Ltd., Montreal, Que.; P. E. Nethercut, TAPPI, New York, N. Y.; J. McK. Limerick, Bathurst Power & Paper Co., Ltd., Montreal, Que.; Mayor Phillips, Toronto; B. Mendlin, Cornell Paperboard Products Co., Milwaukee, Wis.

Ont. This year the conference was sponsored jointly by the Corrugated Containers Division of TAPPI and Corrugated Containers Committee, Technical Section, CPPA. The chairmen of the sponsoring organizations are B. Mendlin, Cornell Paperboard Products Co., Milwaukee, Wis., and R. H. McGee, Bathurst Power and Paper Co., Ltd., Montreal, Que., respectively.

Mayor of Toronto, Hon. N. Phillips

A total of 438 men, including 115 from Canada and one from Australia attended this conference, making it the second largest conference, being outranked by the Seventh Conference in Philadelphia in 1957 when the attendance was 457.

This was the first Corrugated Containers Conference to schedule two days, rather than one, for technical sessions. The excellent technical program under the direction of cochairmen R. W. Buttery, Bathurst Containers, Ltd., Montreal, Que. (for TAPPI) and R. H. McGee (for Technical Section, CPPA) easily verified the anticipated need for the extra day.

The theme for the Tuesday technical sessions was "Meeting Modern Trends for Improved Printing on Corrugated Board." An outstanding feature of the afternoon session was the exhibition of a 25-min., color, sould film "Operation Printer Slotter." This film, produced under the direction of G. R. Wilmer, Packaging Corp of America, Grand Rapids, Mich., chairman of the TAPPI Raw Materials Committee, sponsors of the Tuesday sessions, demonstrated the proper adjustments of printing dies and their use to obtain top quality and to reduce costs. The film was a vivid follow-up of the subjects discussed during the morning session.

The theme for the technical sessions on Wednesday was "New Developments in Packaging" and seven informative papers were presented on this theme.

The papers were published in the December, 1960, issue of *Tappi*.

The Hon. N. Phillips, Mayor of Toronto, extended greetings to the attendants of the conference at the Wednesday luncheon. After a few remarks by J. R. Lientz, Union Bag-Camp Paper Corp., president of TAPPI, and chairman of the Technical Section, CPPA, Mr. Lientz presented TAPPI certificates of appreciation to B. Mendlin, Cornell Paperboard Products Co., Milwaukee, Wis., Corrugated Containers Division chairman; R. W. Buttery, Bathurst Containers, Ltd., Montreal, Que., Production Committee chairman; R. C. Hutcheson, Union Bag-Camp Paper Corp., Spartanburg, S. C., Engineering Committee chairman; H. W. Seibel, Crown Zellerbach Corp., St. Louis, Mo., Process and Quality Control Committee; and to T. W. Carroll, Owens-Illinois Glass Co., Toledo, Ohio, Industrial Engineering Committee chairman.

On Thursday, about 202 or those attending the conference on an all-day tour visited three modern corrugated container plants in the Toronto area: Hinde and Dauch, Ltd., Etobicoke, Ont.; Bathurst Containers, Ltd., Hamilton Ont.; and Hygrade Containers, Ltd., Rexdale, Ont. Luncheon was served at Brant Inn, Burlington, Ont., located on the shore of Lake Ontario.

Another "first" was scored at this conference: a ladies' program was arranged for the wives attending the conference

J. R. Lientz, Union Bag-Camp Paper Corp., Savannah, Ga.; D. Jones, CPPA, Montreal, Que.; J. J. Koenig, Crown Zellerbach Corp., St. Louis, Mo.; R. W. Buttery, Bathurst Containers, Ltd., Montreal, Que., Canada; J. Wooley

L. D. Richardson; W. R. Hilton; E. J. Head, Bathurst Containers, Ltd., Toronto, Ont.; S. M. Johnson, Continental Can Co., Toronto, Ont., Canada; H. O. Teeple, TAPPI, New York, N. Y.

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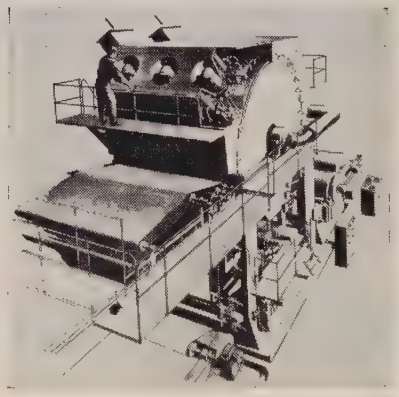

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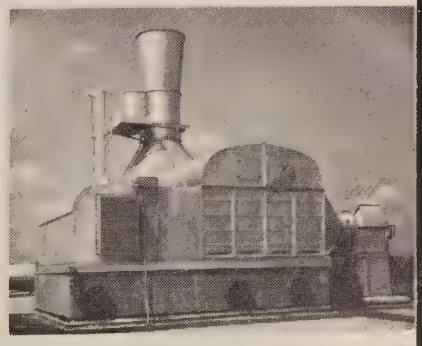

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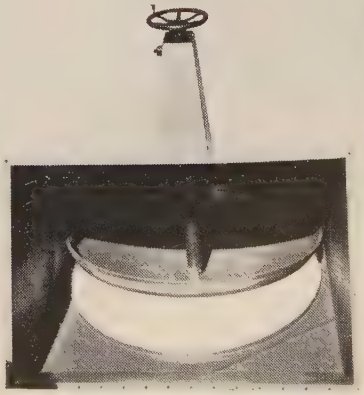


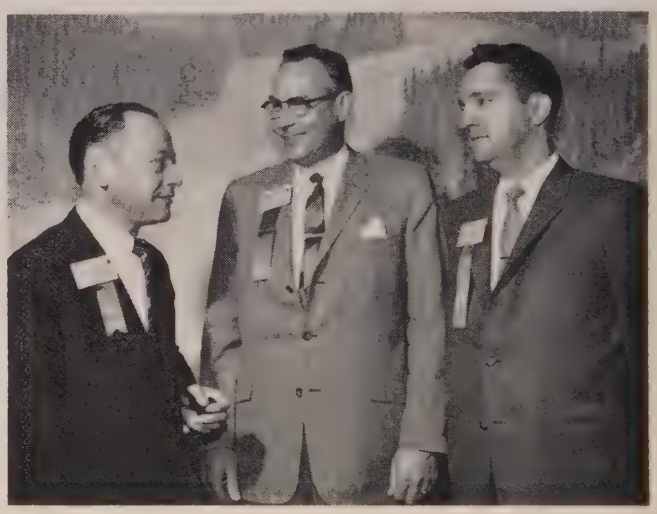
Visit Us at the Biltmore Hotel During the TAPPI Annual Meeting

Session I: D. M. Davis, Moderator, Hercules Box Co., Columbus, Ohio. Authors: G. A. Browne, Perma-Flex Industries, Ltd., Toronto, Ont.; R. W. Reid, General Printing Ink Co., Cincinnati, Ohio; H. J. Devon, Jas. H. Matthews & Co., Pittsburgh, Pa.

Session II (Front): D. M. Davis, Hercules Box Co., Columbus, Ohio; G. A. Browne, Perma-Flex Industries, Ltd.; R. W. Reid, General Printing Ink Co., Cincinnati, Ohio; H. J. Devon, Jas. H. Matthews & Co., Pittsburgh, Pa. (Back): G. A. Bidgood, Bathurst Containers, Ltd.; W. Stevens, Hygrade Containers, Ltd.; R. V. G. Corbett, Hinde & Dauch, Ltd., H. C. Barnes, Continental Can Co. of Canada

Session III: H. J. Ostrowski, Moderator, Hinde & Dauch, Ltd., Toronto, Ont.; A. C. Beardsell, The Mead Corp., Cincinnati, Ohio; W. J. Smith, Union Bag-Camp Paper Corp., New York, N. Y.; J. G. Turk, Glass Containers Manufacturers Institute, Inc., East Lansing, Mich.; D. S. Brown, Atlantic Refining Co., Philadelphia, Pa.; C. J. Kremer, Atlantic Refining Co., Philadelphia, Pa.

Session IV: H. S. Inman, Moderator, Continental Can Co. of Canada, Ltd., London, Ont.; J. G. Reynolds, Bathurst Power & Paper Co., Ltd., Montreal, Que.; D. B. Black, Continental Can Co. of, Canada, Ltd., Toronto, Ont.; R. A. Jamison, Reliance Electric & Engineering Co., Cleveland, Ohio



B. Mendlin, Cornell Paperboard Products Co., Milwaukee, Wis.; R. W. Buttery, Bathurst Containers, Ltd., Montreal, Que., Canada; R. H. McGee, Bathurst Power & Paper Co., Ltd., Montreal, Que.

B. Mendlin (left), Cornell Paperboard Products Co., Milwaukee, Wis.; J. R. Lientz (right), Union Bag-Camp Paper Corp., Savannah, Ga.

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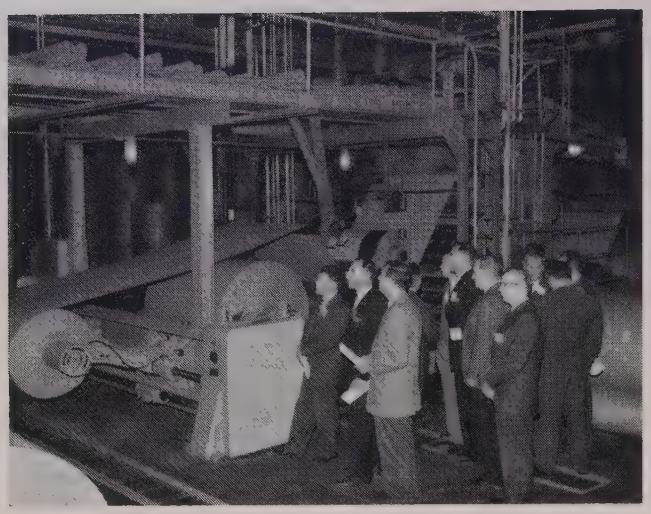

Group watching corrugator at Hinde & Dauch at Canada plant near Toronto

with their husbands. About 65 ladies participated in the well arranged but modest program.

The conference committee was headed by R. W. Buttery, Bathurst Containers, Ltd., Montreal, Que., who also is chairman of the Production Committee of the TAPPI Corrugated Containers Division. Members of his conference committee are as follows:

Treasurer: H. O. Teeple, TAPPI, New York, N. Y.
Secretary: D. M. Farrell, Bathurst Containers, Ltd., Montreal, Que.
Technical Program: Messers. Buttery and McGee
Publicity: W. G. James, St. Lawrence Corp., Ltd., Montreal, Que.
Local Arrangements: W. J. Hurrell, Hinde and Dauch, Ltd., Etobicoke, Ont.
Registration: E. J. Head, Bathurst Containers, Ltd., Toronto, Ont.
Hotel Arrangements: S. M. Johnson, Gair Paper Products Div., Continental Can Co. of Canada, Ltd., Toronto, Ont.
Hospitality: J. F. Hughes, Hygrade Containers, Ltd., Rexdale, Ont.
Mill Tours: H. S. Godwin, Bathurst Containers, Ltd., Toronto, Ont.
Advisory: R. A. Joss, Technical Section, CPPA Montreal, Que.; H. O. Teeple, TAPPI, New York, N. Y.

On Monday, the Steering and Advisory Councils held a joint meeting and the five Corrugated Containers Division committees, Engineering, Industrial Engineering, Process and Quality Control, Production, and Raw Materials, also held meetings. The Containers Testing Committee, of the TAPPI Testing Division, also met on Monday.

Group watch printing process at Hinde & Dauch Paper Co. plant at Toronto

Fifteenth Engineering Conference

The Fifteenth Engineering Conference was held on Oct. 24–27, 1960, at the Robert Meyer Hotel in Jacksonville, Fla. This was a largest Engineering Conference, there being 926 men in attendence.

The format of the conference was changed from that of former years in that technical sessions were scheduled for four, instead of three days and that an afternoon, Tuesday, was scheduled for mill tours rather than a full day, i.e., Thursday, at past conferences. The new format permitted the better scheduling of concurrent technical sessions with a minimum of conflict of subject interest.

There were 18 technical sessions involving 55 papers and five panel discussions during the three and one-half days of the conference. A total of 105 authors and panel members participated in the program. Thirteen of the 15 committees of the Division contributed portions of the program with some committees sponsoring two sessions.

The Engineering Division, for the first time, arranged for preprints of the conference papers. Forty-five of the papers were preprinted and were distributed to those registering for the conference.

During the conference, the 15 committees of the Division held meetings.

A high limit of the conference was a talk on "Nuclear Power for Industry" by Dr. Walter H. Zinn, Combustion Engineering, Inc., Windsor, Conn., at the banquet on Wednesday, Oct. 26, 1960. Also at the banquet, after a few remarks, TAPPI President J. R. Lientz, Union Bag-Camp Paper Corp., Savannah, Ga., presented certificates of appreciation to retiring committee chairmen E. H. Olmstead, Eaton Dikeman Co., Mt. Holly Springs, Pa., Staff Advisory Committee; J. K. Powell, Bowaters Southern Paper Corp., Calhoun, Tenn., Process Instrumentation Committee; and to S. G. Holt, Consolidated Water Power and Paper Corp., Wisconsin Rapids, Wis., Drying Committee. Special certificates were presented to retiring secretaries V. P. Owens, Combustion Engineering Co., Windsor, Conn., Engineering Division secretary, and H. A. Stoess, Jr., Fuller Co., Catasauqua, Pa., Industrial Engineering and Materials Handling Committee secretary.

M. J. Osborne, Bowaters Southern Paper Corp., Calhoun, Tenn., Division chairman was also conference chairman. The technical program was arranged by V. P. Owens, assisted by G. E. Shaad, General Electric Co., Schnectady, N. Y. Division secretary-designate. Local arrangements were directed by J. B. Peebles, Jr., General Electric Co., Jacksonville, Fla. Mr. Peebles committee was as follows:

Local Arrangements Committee
Chairman: J. B. Peebles, Jr., General Electric Co., Jacksonville, Fla.

Ladies Program Committee; Mrs. L. C. Crowder, chairman

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Dicalite BULK-AID is an amorphous mineral, technically an aluminum silicate, produced from a volcanic mineral known as perlite by a special process developed by Great Lakes Carbon Corporation. BULK-AID is inert, insoluble in water, acid or mild alkalies. It is grit-free, and exhibits no reaction with alum in sizing or with other papermaking chemicals. It is readily dispersed in any furnish, does not cause foam, and will not fill felts.

Among BULK-AID's physical characteristics are these:

Color: White
Average G.E. Brightness: 83

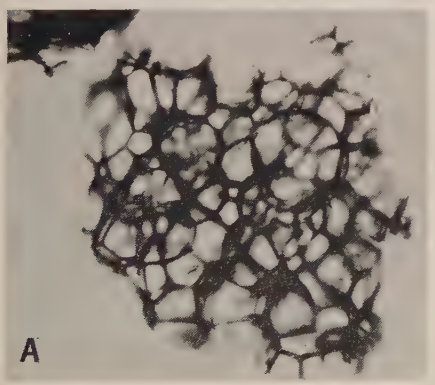
Loose weight: 4½ lbs/ft^3 average

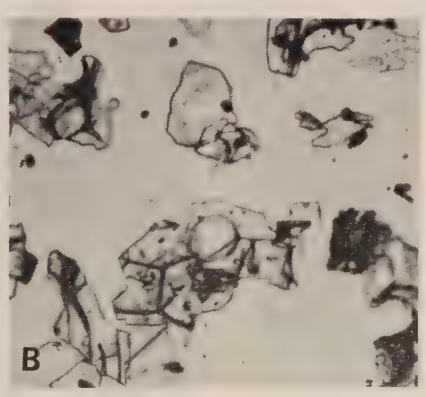
Bulk densities in paperboard: 15 lbs/ft^3 average.

Particle size: 80% less than 10 microns

Extensive testing has shown BULK-AID to be successful in actual paper mill production. Most of these tests were on cylinder machines for paperboard production, but limited tests indicate its value in many slow speed fourdrinier applications.

Your Dicalite engineer will be glad to discuss BULK-AID with you and to advise on possible product applications in your own plant.





When perlite is crushed and then suddenly heated to the proper point in its softening range, it pops like corn into particles like that shown in photomicrograph A, containing a myriad of microscopic sealed cells. The size of the original particle and the application of heat are both important, and are critically controlled. This is the expanded material from which BULK-AID is produced. Controlled milling and air classification by an exclusive Great Lakes Carbon Process are the major steps in making BULK-AID, typical particles of which are shown in photomicrograph B.

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Gordon G. Halvorsen

DICALITE'S "MAN ON THE SPOT"

The development of Bulk-Aid, to meet the industry's need for an extremely low density bulking agent, was initiated by Gordon Halvorsen, Product Sales Manager for Dicalite, and he has been closely identified with its tests and product application work from the beginning.

Halvorsen has an extensive background in research and development work, beginning with his graduation from the University of Minnesota with a degree in Chemical Engineering. Prior to joining Great Lakes Carbon in 1940, Gordon had been engaged in technical and laboratory work in the pharmaceutical, corn processing and water treatment fields, and continued his research work in the Dicalite product laboratories for the first 5 years of his association.

Halvorsen is the author of several technical papers, and has contributed to both paper industry and brewing publications. Among his technical society memberships he lists TAPPI, American Society of Sugar Beet Technologists, Master Brewers Association of America, and others in the brewing and drycleaning fields.

NEW DATA SHEET

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Session II (Paper 6) (Seated): J. R. Fielding, J. F. Fenske, R. W. Foster. (Standing): J. V. Cundelan, J. J. Kimmel, Q. W. Heim, G. C. Werner

Session IV: C. A. Lee, A. E. Scheidegger, W. L. Ingmanson, J. D. Parker, H. D. Wilder

Session II: S. Andersen, J. Davey, H. A. Wright, C. C. Collins, C. G. Herrington

Session V: E. F. Thode, R. W. Van Duyne, W. E. Winans

Session III: A. W. Plummer, W. R. Marshall, L. Zabel, S. A. Zieminski

Session VI (Paper 19 Panel): S. G. Holt; J. J. Killian; P. H. Murphy; W. E. McGough, Olin Mathieson Co., West Monroe, La.; J. G. Coats, Jr., Bowaters Southern Paper Corp., Calhoun, Tenn.; J. W. Taylor

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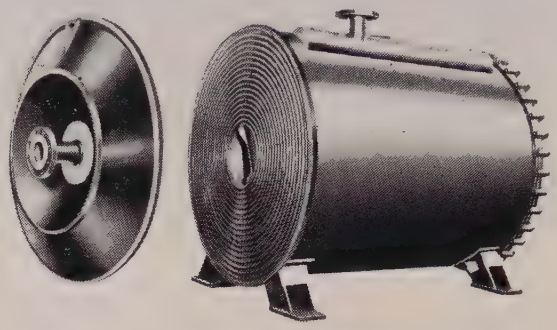

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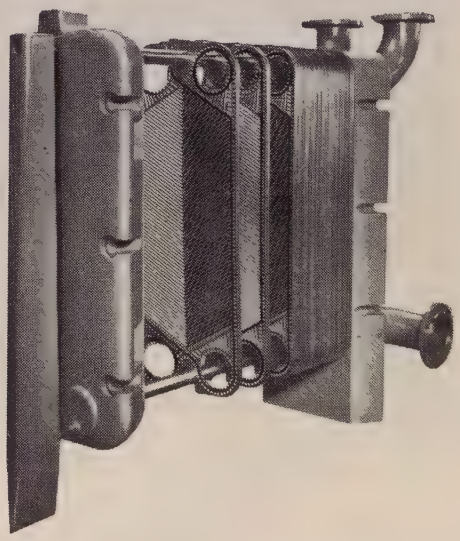

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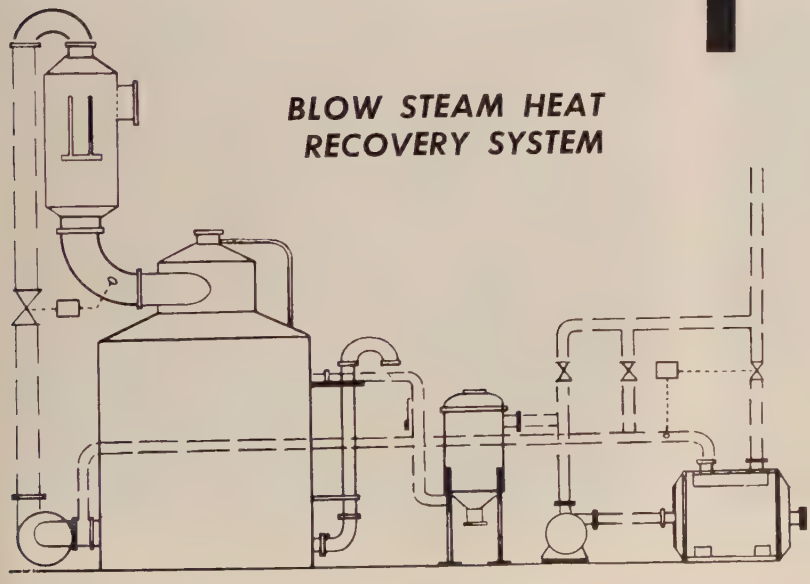

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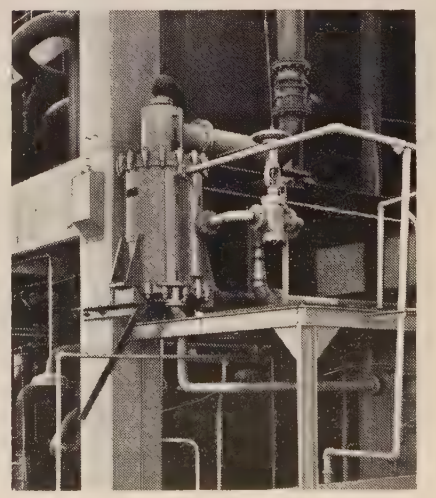

Session VII: H. M. Reed, Jr., C. H. Johnson, P. J. Mitchell, F. J. Hrabak

Session IX: L. R. Vianey, F. J. Prince, O. Wagner, E. S. Mack

Session VII (Paper 23 Panel): H. M. Reed, Jr., H. W. Smith, H. P. Evans

Session X: W. Pittam, W. Swiger, C. Elliott Bouis

Session VIII: J. S. Mudgett, J. E. Perkins, J. W. Riese, J. P. Munton, F. A. Taska, D. R. Dalzell

Session XI: G. W. Sargent, J. G. Nagro, W. A. Smiley, S. G. Holt

Session XII: W. A. Moggio, R. D. Hoak, L. G. Von Lossberg, L. Moore

Session XIV (Paper 46 Panel): T. F. Woodford, M. S. Ginter, W. S. Tierney, J. W. Herrington

Session XIII (Seated): P. Wrist, A. C. Spengos, C. L. Clark. (Standing): W. B. Debler, J. Mardon

Session XV: E. W. Hopper, E. G. Holmberg, R. E. Gackenbach, J. M. Jopp, R. A. Davis

Session XIV: H. R. Emery, R. A. Dando, L. Limon, H. R. Arnold

Session XVI: B. Kendall, H. A. Stoess, H. J. Sundahl, R. G. Carter

Session XVII: J. K. Powell, R. B. Hurm, E. J. Trimbey, D. P. Michel, E. W. Prince

Banquet: J. B. Peebles, Jr., Dr. W. H. Zinn, M. J. Osborn, Mrs. L. C. Crowder, J. R. Lientz, P. E. Nethercut

Session XVIII: H. B. Harris, H. M. Canavan, G. E. Linnert, K. L. Crooks

Banquet: H. O. Teeple, W. A. Moggio, E. W. Hopper, J. K. Powell, G. E. Shaad, S. Andersen, T. S. Coldewey, N. Shoumatoff, Rev. Gladstone Rogers

Session XVIII (Paper 60 Panel) (Seated): E. W. Hopper, D. Innes, E. D. Whitehead. (Standing): M. E. Cyr, D. K. Kingsbury, G. E. Linnert, C. R. Jehn

Banquet: S. G. Holt, H. G. Ingraham, E. H. Olmstead, J. D. Lyall, C. A. Lee, A. J. Winchester

Banquet: G. E. Shaad; S. Andersen; T. S. Coldewey, St. Joe Paper Co., St. Joe, Fla., Pres. of PIMA; N. Shoumatoff; Rev. Gladstone Rogers, All Saints Parish Episcopal Church, Jacksonville, Fla.; J. B. Peebles, Jr.; Dr. W. H. Zinn

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Hospitality: A. J. Stockslager, Reliance Electric and Engineering Co., Jacksonville, Fla.; J. B. Chandler, J. B. Chandler, J. B. Chandler Co., Atlantic Beach, Fla.; P. L. Poland, General Electric Co., Jacksonville, Fla.; J. T. Vincent, General Electric Supply Co., Jacksonville, Fla.; A. McDowell, Allis Chalmers Mfg. Co., Jacksonville, Fla.; D. C. Barnes, Westinghouse Electric Co., Jacksonville, Fla.; M. D. Duncan, M. D. Duncan Associates, Jacksonville, Fla.; R. V. Pennington, Owens-Illinois, Jacksonville, Fla.

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Publicity: R. E. Phillips, St. Regis Paper Co., Jacksonville, Fla.; E. P. Athens, Westinghouse Electric Corp., Jacksonville, Fla.

Mill Tours: H. Westberry, Owens-Illinois, Jacksonville, Fla.

Ladies' Program Committee: Mrs. L. C. Crowder, *chairman;* Mrs. J. B. Peebles, Jr., *secretary;* Mrs. W. B. Hobbs; Mrs. H. R. Emery; Mrs. R. F. Sorenson; Mrs. F. A. Adams; Mrs. J. E. Baber; Mrs. F. W. Elser

Banquet: P. E. Nethercut, R. G. Macdonald, W. C. Bloomquist, K. O. Elderkin, D. Jones, V. P. Owens, A. W. Plummer, S. G. Holt

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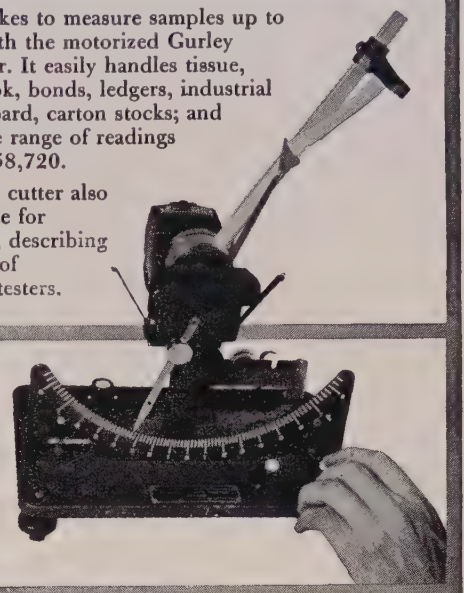

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An interesting facet of the conference were speeches on the pulp and paper industry delivered to some of the service luncheon clubs meeting in Jacksonville. K. O. Elderkin, Bowaters Engineering and Research Co., Calhoun, Tenn., and past president of TAPPI, presented a talk before the Downtown Rotary Club; M. J. Osborne spoke at the Downtown Kiwanis Club; J. D. Lyall, Armstrong Cork Co., Lancaster, Pa., and past chairman of the Engineering Division spoke before the Meninak Club; and W. T. Webster, H. K. Ferguson, Inc., gave a talk before the Southside Rotary Club.

In keeping with TAPPI's industry educational program, J. B. Peebles, Jr., arranged for complimentary conference registrations for 26 Jacksonville participants in the Joe Berg Foundation program thus enabling these outstanding high school students to attend the technical sessions and gain an insight into the engineering aspects of the pulp and paper industry.

"The Joe Berg Foundation proposes that seminars be established throughout the nation to provide extracurricular training for selected gifted students. This educational program will offer students of exceptionally high ability instruction in scientific concepts, methods, and applications. This instruction is more advanced, rigorous, and individualized than that which could possibly be offered under the regular curriculum. It is distinguished in that it successfully enlists as members of a single cooperative team the technologists and professional scientists of the community."

A modest but most interesting Ladies' Program was arranged under the direction of Mrs. L. C. Crowder with enthusiastic participation by 160 wives of men attending the conference.

On Tuesday afternoon, a large number of the men visited St. Regis Paper Co. and Owens-Illinois Glass Co. in Jacksonville.

TAPPI NOTES

The Allied Industries and TAPPI

The term "allied industries" as used in this text refers to the manufacturers and distributors of machinery, equipment, and other commodities sold to pulp and paper and paper converting companies.

Over the years, since the Technical Association was established in 1915, the allied industries have been represented in its membership, first by individuals who were properly qualified and since 1929 by the companies themselves. The company members were first designated as contributing members. At present they are known as sustaining members. Companies in a similar group in the Paper Industry Management Association are called allied affiliates.

Individual employees of companies in the allied industries may become personal members of the Association. Depending upon their experience and education they can become active or associate members. Librarians of such companies frequently become affiliate members.

Since individual members are members in their own right and are not officially representatives of companies they may participate fully in the activities of the Association.

They receive the same publications and services as members of identical grades in pulp and paper companies. They serve on committees of the Association, attend national and sectional meetings, author chapters of monographs, prepare and present meeting papers and participate fully in the affairs of the Association.

Many employees of companies in the allied industries have been chairmen of committees and local sections and have given much of their time to handling details of national conferences. Since 1944 the allied industries have been represented on the national executive committee and these representatitives participated in formulating the overall policies of the association.

During any calendar year there are hundreds of changes made in the membership roster of the association. Members are promoted, they change jobs, they enter or leave the industry. Some members, employed by paper companies, join the staff of companies in the allied industries. Other allied industry men transfer their services to pulp and paper manufacturers.

The education of nearly all members of the Association is similar. They, for the most part, are graduate engineers or chemists. Many are graduates of colleges and universities having special pulp and paper courses that are based on the engineering sciences. When they graduate they may be employed by a pulp and paper company or by a company in one of the allied industries. In either case, their interest in the Technical Association is based on work that they may be doing for a paper company or for a company that has a special interest in some aspect of pulp and papermaking or paper conversion. It is not unusual, therefore, that over a period of years a person may change his employment from or to a company in the paper industry or to or from a company serving the industry in an important way as a supplier.

The pulp and paper industry, together with its converting plants constitute a market for a large number of industries. In these allied industries there are many companies that have special services to offer the paper industry.

There is a perpetual need for mutual education. Representatives of supply companies need to have intimate knowledge about the paper industry so that they may know how best to serve it. The engineers, operators, and technical men of the paper industry need to be knowledgeable about the new equipment, machinery, and commodities needed by the industry. In many cases the applications are special, somewhat different from the application of similar items in other industries.

The clearing house for this exchange of information is the professional society. There are many professional societies serving the fields of engineering, the sciences, technology, management, etc., in the pulp and paper industry. The Technical Association of the Pulp and Paper Industry is the melting pot of all of these primary interests.

The allied industries endeavor to educate the paper industry by having sales and service engineers maintain close relations with individual companies by direct visits. It arranges to have its technical specialists participate in the program of the Technical Association by attending conferences and committee meetings, presenting papers containing useful new information about their products and special applications, and meeting with paper mill representatives for whom the conferences are planned.

In addition the allied industries use the advertising pages of *Tappi* and the trade magazines to focus attention on certain products and services being made available to the paper industry. It is assumed that the aim of every company is to make a satisfactory product at a competitive cost that will permit a profit. The customer dictates the discipline of the supplier. In this case the supplier is the paper industry. The paper industry needs all of the factual information that it can get from all sources—its own research and operating men, its sales representatives and from all branches of the allied industries. TAPPI, for 45 yr. has presented the common ground, through its meetings and publications to facilitate the necessary exchange of knowledge between workers in pulp and paper and converting industries and all of the allied industries that can make valued contributions of information.

Ronald G. Macdonald
Treasurer and Editorial Director

TAPPI PROFILES

Piero Bersano

Piero Bersano, chairman of the Italian Section of TAPPI, was born in Fossano (Cuneo), Italy, on April 13, 1908. After completing his primary education in Turin, he attended the Polytechnic School of Turin where he obtained his degree in electromechanical engineering in 1930.

In the same year, through a scholarship, he joined Cartiere Burgo, the most important and largest paper group in Italy, and was appointed to the Verzuolo mill where he was employed in maintenance and production work. In December, 1933, he joined the Technical Department at the Head Offices of this company, in Turin.

Six years later Dr. Bersano was appointed a deputy director of the technical department, and in 1946, he became its director, a position which in the United States corresponds to that of vice-president in charge of manufacturing, engineering, and research. As head of the technical department he undertook the modernization of the plants in the various mills of Cartiere Burgo, and by installing four new paper machines and substantially modifying others, he succeeded in doubling the company's prewar production figure. He also initiated the first plant for the continuous cooking of straw, following the Kamyr system, and has participated directly in studies for the development of this process.

Mr. Bersano has been a member of TAPPI since 1947; in 1958 he became one of the founders of the Italian Association of TAPPI Members, and was named chairman. The object of this Association was to assemble the Italian members of TAPPI into a single organization, and such was its success that in 1959 the TAPPI Executive Committee resolved to grant it a charter of Italian Local Section. Mr. Bersano held the chairmanship of this Section during 1959, and in 1960 was re-elected chairman.

He is a member of the TAPPI Mechanical Pulping Committee and is vice-president of ESPRA and of the European Study Group of TAPPI. Well known in both European and North American technical circles, he has undertaken a campaign in Italy to promote the best use of Italian timber, particularly hardwood, in the paper industry. At present he is engaged in an intensive research program at Cartiere Burgo, on both high-yield sulfite pulp and groundwood, a field in which he has obtained excellent results.

He is now a member of the Board of Directors of Natro Cellulose Co., manufacturers of multiwall bags; of the SIDIN Co., which owns a group of hydroelectric power plants he has helped to design and build and which feed Cartiere Burgo; of the Beloit Italia Co., an international company manufacturing paper machines; of the Burgo-Bowater-Scott S.P.A.; and of the Cartiera di Fossano.

A past-president of the Rotary Club of Cuneo (1946–47), he is at present a member of the Rotary Club of Turin.

PERSONAL MENTION

New TAPPI Members

James C. Adam, Senior Designer, Beloit Iron Works, Beloit, Wis., a 1949 graduate of University of British Columbia.

A. Ross Adams, Chemist, Avison, Philadelphia, Pa., a 1949 graduate of Harvard University, with a Ph.D degree in 1952 from University of Delaware.

Gilles M. Alarie, General Production Superintendent, Richmond Pulp & Paper Co. of Canada, Ltd., Bromptonville, Que., Canada, a 1950 graduate of Institute of Pulp & Paper Technology.

LeMoyne W. Anderson, Director of Libraries, Colorado State University, Fort Collins, Colo.

Benjamin P. Astley, General Sales Manager, B. F. Perkins & Son, Inc., Holyoke, Mass., a 1948 graduate of Northeastern University.

Frank C. Bacon, Vice-President, Capital Wire Cloth Western, Ltd., New Westminster, B. C. Attended University of British Columbia.

Rene Barry, Secretary-Manager, the Quebec Lumber Manufacturers' Association, Quebec, Que., a 1948 graduate of Laval College.

Joseph J. Becher, Research Aide, the Institute of Paper Chemistry, Appleton, Wis., a 1949 graduate of Lawrence College.

Carl W. Bieber, Textile Consultant, Carl W. Bieber, Summit, N. J.

Frederick B. Burns, Engineer, Fibre Products, Line Material Industries, West Allis, Wis., a 1954 graduate of Missouri School of Mines.

Edwin R. Burr, Assistant Mill Manager, Owens Illinois Glass Co., Mill Div., Valdosta, Ga., a 1950 graduate of University of Wisconsin.

Edmond W. Carney, Product Development Engineer, West Virginia Pulp & Paper, Hinde and Dauch Div., Sandusky, Ohio, a 1959 graduate of Rensselaer Polytechnic Institute.

Leroy L. Carney, Chemist, Magnet Cove Barium Corp., Houston, Texas, a 1956 graduate of Louisiana State University.

Sukumor Chatterjee, Technical Manager, Suhrid Geigy Trading Private, Ltd., Bombay, India, a 1950 graduate of University of Basle, Switzerland, with a Ph.D degree.

Ronald R. Christian, Associate Technologist, Applied Research Laboratory, United States Steel Corp., Monroeville, Pa., a 1950 graduate of Hiram College.

Stephen R. Collins, Student, University of Maine, Orono, Me., a 1960 graduate of University of Maine.

Pierre Corbineau, General Manager, Ets. Martel, Catala & Cie, Selestat (Bas-Rhin), France.

Horst Croenert, Pulp Chemist, Escher Wyss G.m.b.H., Ravensburg/Wttg, Germany, a 1959 graduate of Darmstadt University with a Ph.D degree.

Paul R. Eastwood, Manager, Product Specifications and Quality Conformance, Kimberly-Clark Corp., Neenah, Wis., a 1929 graduate of University of Wisconsin.

Rockie R. Egner, Chemical Engineer, Moore Business Forms, Inc., Emeryville, Calif., a 1957 graduate of University of Notre Dame.

Clement W. Elble, District Manager, Swenson Evaporator Co., New York, N. Y., a 1933 graduate of University of Cincinnati.

Robert H. Fleck, Sales Service Representative, The Mead Corp., Chillicothe, Ohio, a 1959 graduate of Western Michigan University.

Burton A. Ford, Laboratory Director, Riegel Paper Corp., Bloomer Div., Newark, N. Y., a 1953 graduate of New York State College of Forestry.

Hugh T. Gardner, Senior Microbiologist, Buckman Laboratories, Inc., Memphis, Tenn., a 1949 graduate of University of Washington.

Marie Gast, Librarian, Cornell University, Ithaca, N. Y.

Gordon M. Girdwood, Manager, Pulp & Paper Sales Div., Dorr-Oliver, Inc., Stamford, Conn. Attended University of California.

Robert J. Hackett, Sulfite & Wood Room Superintendent, St. Croix Paper Co., Woodland, Me.

Lars B. Hall, Development Engineer in charge of Sulfite Mill, Munksjo, AB Jonkoping, Sweden, a 1957 graduate of Royal Institute of Technology.

Ralph S. Healey, Field Engineer, Elliott Co., Atlanta, Ga., a 1950 graduate of Georgia Institute of Technology.

Peter C. Hereld, Director of Development, Sun Chemical Corp., New York, N. Y.

John S. Hermon, Resident Manager, St. Lawrence Corp., Ltd., Montreal, Que., a 1934 graduate of Ottawa College.

Samuel D. Hodge, Superintendent, Bloomer Bros., Newark, N. Y.

Richard R. Holmes, Development Engineer, Celanese Fibers Co., Charlotte, N. C., a 1953 graduate of Centre College.

William O. Hund, Assistant Chief Chemist, Standard Lime & Cement Co., Div. of American Marietta Co., Martinsburg, W. Va., a 1954 graduate of Grove City College.

Gordon M. Ide, Research Associate, Merck & Co., Rahway, N. J., a 1941 graduate of Dartmouth College.

Toshio Imbe, Technical Director, Takahagi Pulp Co., Ltd., Wakayama City, Japan, a 1938 graduate of Nagoya Technical College.

Charles E. Jackson, Divison Engineer, Portland Overlay Welding Div., Chicago Bridge & Iron Co., Portland, Me., a 1950 graduate of University of Maine.

Thomas D. Johannson, Production Manager, Martin Paper Products, Edmonton, Canada, a 1950 graduate of University of Manitoba.

John R. Johnstone, Plant Superintendent, Spaulding Fibre Co., Inc., North Rochester, N. H., a 1957 graduate of University of New Hampshire.

Donald M. Keagy, Regional Air Pollution Representative, United States Public Health Service, San Francisco, Calif., a 1949 graduate of Pennsylvania State University.

Harry J. Kiefer, Research Chemist, the Glidden Co., Cleveland, Ohio., a 1952 graduate of Oregon State University with a Ph.D. degree.

William A. Kirn, Jr., Manager, Claremont Paper Mill, Claremont, N. H., a 1933 graduate of Oxford Business College.

Stanley E. Knowles, Associate Director, the Mead Corp., Chillicothe, Ohio, a 1941 graduate of Iowa State College.

Richard E. Kolb, Consulting Engineer, Worms, Germany, a 1934 graduate of Darmstadt University, with a D.Eng. degree in 1957.

Goran Kull, Research Assistant, Central Laboratory of the Swedish Cellulose Industry, Stockholm, Sweden, a 1958 graduate of the Royal Institute of Technology.

John J. Lane, Chemist, Titanium Pigment Corp., New York, N. Y., a 1950 graduate of Syracuse University.

Milton Lite, Consulting Engineer, Greenville, S. C., a 1943 graduate of College of the City of New York.

Ralph L. Lougheed, Service Engineer, R. T. Vanderbilt Co., Inc., New York, N. Y., a 1955 graduate of Tri-State College.

Francisco Matarazzo, Vice-President and Adminstrator Manager, Reysol S.A., Buenos Aires, Argentina.

C. Dana McCoy, Pulp & Paper Director, Walter Kiddie Engineers, Inc., New York, N. Y., a 1926 graduate of Yale University.

Michael M. Merriman, Junior Specialist, Forest Products Laboratory, University of California, Richmond, Calif., a 1956 graduate of Iowa State University.

Walter C. Miller, Vice-President, Falls Paper & Power Co., Oconto Falls, Wis., a 1940 graduate of University of Minnesota.

Toivo Nieminen, Chief Engineer, Valmet Oy Lentokonetehdas, Tampere, Finland, a 1934 graduate of Technical University, Helsinki.

Robert H. Oertli, Project Engineer, Owens-Illinois Glass Co., Mill Div., Tomahawk, Wis., a 1948 graduate of Montana State College.

Harold D. Orloff, Research Supervisor, Ethyl Corp., Ferndale, Mich., a 1940 graduate of University of Manitoba.

Forrest C. Palmer, Director of Libraries, Mitchell Memorial Library, Mississippi State University, State College, Miss.

Henry R. Patterson, Jr., Chief Engineer, Beloit Eastern Corp., Downingtown, Pa., a 1935 graduate of Carnegie Institute of Technology.

Phillip B. Pickering, Field Service Engineer, Huyck Felt Co., Rensselaer, N. Y., a 1952 graduate of U. S. Military Academy.

Vincent J. Plansky, Salesman, the Dow Chemical Co., Midland, Mich., a 1951 graduate of Boston, College.

Theodore L. Poplawski, Salesman, Diamond Alkali Co., Chicago, Ill., Attended University of Wisconsin.

J. Robert Potter, Vice-President, Lockwood Greene Engineers, Inc., Boston, Mass., a 1930 graduate of Pennsylvania State University.

John R. Redgrave, Division Sales Manager, Beloit Iron Works, Beloit, Wis. Attended Rittenhouse College.

George Ries, Sales Engineer, Western Machinery Co., WEMCO Div., San Francisco, Calif., a 1950 graduate of DePaul University.

James E. Salzer, Vice-President, John H. Marvin Co., Inc., Seattle, Wash., a 1951 graduate of Whitman College.

C. Sandill, Chief Chemist, Bharat Carbon & Ribbon Mfg. Co., Ltd., Punjab, India, a 1951 graduate of Punjab University.

Donald H. Severson, Mill Manager, Neenah Paper Div., Kimberly-Clark Corp., Neenah, Wis., 1932 graduate of University of Wisconsin.

Bernard C. Smith, Group Leader, U. S. Rubber Co., Naugatuck, Conn., a 1950 graduate of St. Michaels College, Vermont.

Charlotte J. Smith, Assistant Group Leader, St. Regis Paper Co., Carthage, N. Y., a 1957 graduate of Syracuse University.

Richard H. Smith, Assistant Sales Manager, Beloit Iron Works, Beloit, Wis., a 1939 graduate of Yale University.

Robert E. Smith, Chief Engineer, Hudson Pulp & Paper Corp., Augusta, Me., a 1948 graduate of Cornell University.

Harold M. Sonnichsen, Director of Fiber and Saturant Research, Dewey and Almy Chemical Div., W. R. Grace Co., Cambridge, Mass., a 1959 graduate of Harvard University.

Richard J. Spangenberg, Sales Engineer, Dorr-Oliver, Inc., Stamford, Conn., a 1955 graduate of Villanova University.

Arthur W. Sperling, Assistant Chief Chemist, Hogan Faximile Corp., New York, N. Y.

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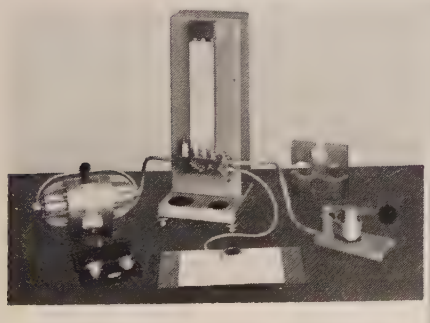

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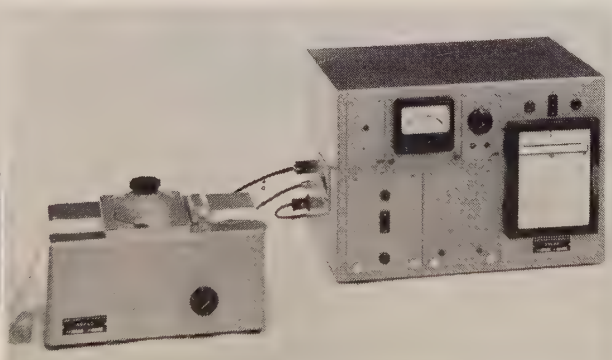

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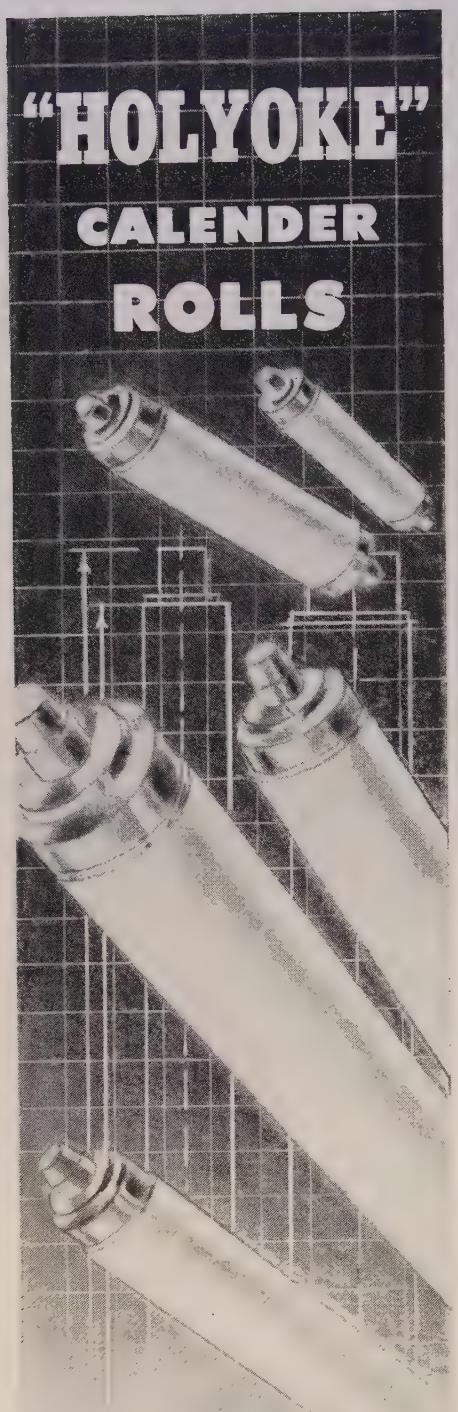

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John B. Stevens, Chief Plant Engineer, Consolidated Paper Co., Monroe, Mich., a 1936 graduate of University of Illinois.

H. Frank Sweeney, Supervisor, Polyolefins Group, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., a 1954 graduate of U. S. Military Academy.

James C. Taft, Chemist, E. I. du Pont de Nemours & Co., Inc., Columbia, Tenn., a 1960 graduate of Vanderbilt University.

David H. Taylor, Associate Director of Research, Time, Inc., Springdale, Conn., a 1937 graduate of Dartmouth College.

Ueno Toru, Manager, Development Research, Sekisui Chemical Co., Ltd., Osaka, Japan, a 1953 graduate of Kushu University.

Katsuyuki Ushida, Director of Research Laboratory, Nippon Wire Cloth Co., Ltd., Tokyo, Japan, a 1944 graduate of Ryozyun College of Technology.

Arnold M. Varner, Technical Director, Standard Packaging Corp., New York, N. Y., a 1947 graduate of Massachusetts Institute of Technology.

Arthur C. Waldron, Industrial Salesman, Virginia Smelting Co., West Norfolk, Va., a 1950 graduate of Mercer University.

Arno G. Weidhass, Research Engineer, Weyerhaeuser Co., Longview, Wash., a 1954 graduate of Technical University of Darmstadt, with a Ph.D. degree in 1960.

Gary L. Weidner, Senior Development Chemist, Atlas Powder Co., Wilmington, Del., a 1954 graduate of Lafayette College.

Thomas A. Willingham, Jr., General Superintendent, West Virginia Pulp and Paper Co., Charleston, S. C., a 1936 graduate of University of Alabama.

Julius E. Wilske, Chief Engineer, Container Machinery Div., Bostitch, Inc., East Greenwich, R. I., a 1928 graduate of University of Illinois.

Appointments

O. P. Aggarwala is now with Beloit International Corp., Zurich, Switzerland.

Charles H. Curgell is now Vice-President of Corite-Reynolds Corp., Des Plaines, Ill.

Salvatore Benedetto, formerly a student at Lowell Technological Institute, is now Chief Chemist of Wood Flong Corp., Hoosick Falls, N. Y.

Richard L. Betts, formerly of Champion Paper & Fibre Co., is now Paper Mill Manager of Bowaters Carolina Corp., Catawba, S. C.

Clayton T. Bockus is now Technical Director of Eastern Fine Paper and Pulp Division of Standard Packaging Co., So. Brewer, Me.

Johannes P. Buitjtenen, formerly of the Institute of Paper Chemistry, is now silverculturist of the Texas Forest Service, College Station, Tex.

L. Baxter Chamberlain has returned from Europa Carton A/S to the Container Corp. of America, Chicago, Ill., as General Manager.

Jack E. Chin, formerly of Consolidated Water Power & Paper Co., is now Assistant Paper Mill Manager of Bowaters Carolina Corp., Catawba, S. C.

C. Duane Coates, formerly of the Escanaba Paper Co., is now Assistant Technical Director of the Mead Corp., Chillicothe, Ohio.

Paul E. Daly, fomerly of Marathon Corp. of New York, is now Technical Control Supervisor of Hammermill Paper Co., Oswego, N. Y.

George C. Davis is now Chief Engineer of Bowaters SouthernPaper Corp., Calhoun, Tenn.

Florimond A. Delforge is now Manager of Engineering Sales and Service for Paper Products, Overseas Division, Continental Can Co., New York, N. Y.

Arthur G. Dreis is now Manager of Paper Chemicals for Newport Industries Div., Heyden Newport Chemical Corp., Pensacola, Fla.

Douglas Duncan, formerly of the Kruger Organization, Ltd., is now Mill Manager of Turcot Paperboard Mills, Ltd., Montreal, Canada.

James J. Eberl is now Assistant Vice-President of the Scott Paper Co., Chester, Pa.

Roderick E. Eddy of Nalco Chemical Co., has been transferred from Chicago, Ill., to Jacksonville, Fla. as District Manager.

Henry O. Ehrisman is now Vice-President and U. S. General Sales Manager of The Foxboro Co., Foxboro, Mass.

Richard C. Erickson, formerly a student at The Institute of Paper Chemistry, is now a Research Chemist with Albernarle Paper Co., Richmond, Va.

Karl O. Glifberg of the Beloit Iron Works, has been transferred from Zurich, Switzerland, to Beloit, Wis.

Claes Hall, formerly of Svenska Cellulose A/B, is now President of Oskarstrom Sulphite Mills A/B, Oskarstrom, Sweden.

Judson Hannigan, Jr., is now Manager of the International Paper Co., Palmer, N. Y.

Willis G. Hartford is now Manager of the Champion International Division of The Oxford Paper Co., Lawrence, Mass.

Peter A. Illing of the West Virginia Pulp & Paper Co., has been transferred from Chicago, Ill., to New York, N. Y., as a customer service representative.

Vernon C. Iverson is now Assistant Superintendent of the Nekoosa-Edwards Paper Co., Port Edwards, Wis.

Valdemar A. Jacobsen of Ciba Co., Inc., has been transferred from Philadelphia, Pa., to Rumford, R. I.

R. Harold Jenkins of Hercules Powder Co., has been transferred from Chicago, Ill. to Wilmington, Del. as Manager of Sales Development.

Jerome Kronfield, formerly of National Starch Products, Inc., is now a Product Engineer for Johnson & Johnson, Permacel Division, New Brunswick, N. J.

Jack E. Lukins, fomerly of Dairypak Butler, Inc., is now a Process Problem Engineer for Kimberly-Clark Corp., Niagara Falls, N. Y.

James E. Maclem, formerly a student at The Institute of Paper Chemistry, is now a Research Engineer for the Beloit Iron Works, Beloit, Wis.

Ralph E. McCallum, formerly of Marathon Corp. of Canada, Ltd., is now a Shift Superintendent of Celgar, Ltd., Castlegar, B.C., Canada.

Winship B. Moody of Hercules Powder Co., has been transferred from Holyoke, Mass., to Savannah, Ga. as a Technical Sales Service Engineer.

Allan M. Mulder, formerly of the Allied Paper Co., is now a Sales Representative for the Ciba Co., Kalamazoo, Mich.

John F. Nolan, formerly of Hamilton Paper Co., is now Paper Mill Manager of Spaulding Fibre Co., Tonawanda, N. Y.

Turam Norta is now Resident Manager of Enso-Gutzeit Oy Imatra and Tainionkoski Mills, Tainionkoski, Finland.

Henry J. Ostrowski is now Technical Director of Hinde & Dauch, Ltd., Toronto, Canada.

Thomas Payne, Pulp Mill Engineer for the International Paper Co., has been transferred from Mobile, Ala., to Moss Point, Miss.

George E. Prentiss of the Oxford Paper Co., has been transferred from Rumford, Me., to Lawrence, Mass. as Production Manager of the Champion, International Division.

H. M. Reed, Plant Engineer for the International Paper Co., has been transferred from Springhill, La., to Mobile, Ala.

Charles N. Rogers, formerly of Sonoco Products Co., is now Director of Engineering for the Celotex Corp., Chicago, Ill.

Diilo E. Ryti, formerly of G. A. Serlachius Oy, is now Technical Manager of Oy Wilh, Schausnan, Jacobstad, Finland.

Chester N. Stupp of the Oxford Paper Co., has been transferred from New York, N. Y., to W. Carrollton, Ohio, as Manager of the Oxford Miami mill.

Robert I. Thieme is now Vice-President in charge of manufacturing operations of Scott Paper Co., Chester, Pa.

John C. Wollwage is now General Manager of Manufacturing Process-Consumer Products, Kimberly-Clark Corp., Neenah, Wis.

James F. Zavatone of Container Corp. of America has been transferred to Hamburg/Wansbek, Germany as head of the Mechanical Packaging Department of Europa Carton A/g.

* * *

J. J. Perot has succeeded *D. Bieri* as the corporate representative of National Gypsum Co., Buffalo, N. Y., in the Technical Association.

* * *

Samuel Loshack has succeeded *W. R. Moffitt* as the official representative of the Borden Chemical Co., New York, N. Y., in TAPPI.

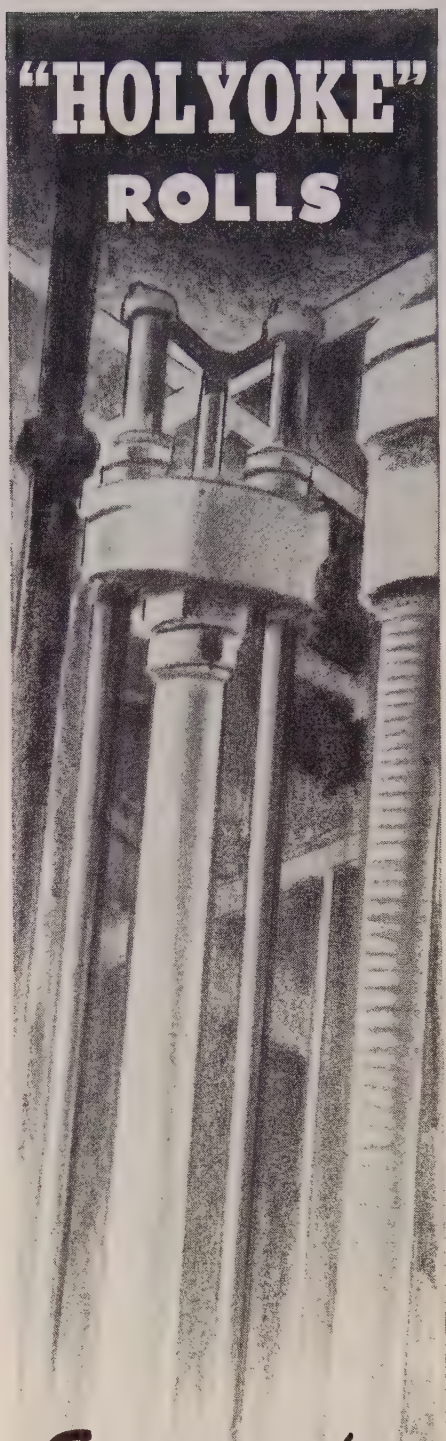
Gex P. Condit, President has succeeded *T. A. Jones* as the official representative of the Manchester Machine Co., Middletown, Ohio.

Vince Vigeron has succeeded *Norman O. Weil* as the official representative of the W. S. Tyler Co., Cleveland, Ohio, in TAPPI.

Kenneth E. Youngchild has succeeded *J. M. Walsh* as the official representative of the American Cyanamid Co., New York, N. Y., in TAPPI.

John R. Nelson has succeeded *R. E. Eddy* as the official representative of Nalco Chemical Co., in TAPPI.

E. Carl Snyder has succeeded *Ach. A. Harden* as the official representative of Corn-Products Sales Co., in the Technical Association.



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CALENDER and EMBOSSING ROLLS
for the PAPER and TEXTILE INDUSTRIES
WATER FILTRATION EQUIPMENT
HOLYOKE, MASSACHUSETTS

INDUSTRY NOTES

North American

Statistics

*Paper and Paperboard Production**

Paper and board production in November, 1960, estimated at over 2.8 million tons, probably exceeded the November 1959 total. The 11-month 1960 total is estimated at 31.7 million tons, up 1.2% from the corresponding 1959 level. Paper production showed a 3.5% gain; paperboard production was virtually unchanged; while construction paper and board production dropped about 1.7% below the year-earlier total. Preliminary estimates place total 1960 productiion at a record 34.4 million tons, up 1.2% from the 34.0 million tons produced in 1959.

*Pulpwood**

Total receipts of pulpwood for January–September were 30,934,000 cords, an increase of 2,797,000 cords over receipts for the comparable period last year. Domestic receipts were 2,700,000 cords above the year earlier total, and imports increased 97,000 cords. All of the regions showed increases ranging from 3% in South Central to 16% in the West regions.

Pulpwood consumption for January–September, 1960, was 30,478,000 cords, an increase of 1,522,000 cords over the same period of 1959. All of the regions showed increases ranging from 1% in South Central to 9% in the North Central region.

Inventories of pulpwood at the end of September were 5,782,000 cords, an increase of 333,000 cords above August, 1960, and a 720,000 cords increase above September, 1959. Two of the regions showed decreases: South Central decreased 1% and Northeast decreased 5%. Three regions showed increases ranging from 5% in North Central to 72% in the South Atlantic region.

*Wastepaper and Other Fibrous Materials**

September wastepaper receipts were 755,000 tons; for the first nine months of this year they totaled 6,722,000 tons, a decrease of 261,000 tons below receipts for last year.

Wastepaper consumption for September was 759,000 tons; the January–September total was 6,771,000 tons, a decrease of 123,000 tons from consumption for the same period last year.

Inventories at the end of September were 538,000 tons, 4000 tons below August and an increase of 14,000 tons above inventories at the end of September, 1959.

Consumption of total fibrous materials for September was 839,000 tons; the January–September total was 7,518,000 tons, 163,000 tons below consumption for the comparable period last year.

Inventories of total fibrous materials at the end of September were 880,000 tons, 24,000 tons below August and 21,000 tons above inventories at the end of September, 1959.

*Wood Pulp**

Production of wood pulp for January–September, 1960, was 18,906,000 tons, an increase of 817,000 tons above the comparable 1959 total.

Wood pulp consumption in the manufacture of paper and board for January–September, 1960, was 19,307,000 tons, an increase of 564,000 tons above consumption for the same peiod last year.

Imports of wood pulp for January–September, 1960, were 1,782,406 tons, 1% below imports for last year. Imports from Canada for January–September, 1960, were 1,523,131 tons, 3% above the comparable period of 1959. Overseas imports for January–September, 1960, were 258,769 tons as compared to 323,774 tons for the same period last year.

Exports of wood pulp for January–September, 1960, were 858,199 tons, as against 479,851 tons exported during the same period last year.

Inventories of wood pulp at paper and board mills at the end of September were 538,228 tons, 5304 tons below inventories at the end of August and 6041 tons above inventories at the end of September, 1959.

Newsprint

In 1960 world demand for newsprint established new records and all major areas of the world are sharing in the gain, according to the latest annual review by the Newsprint Association of Canada.

There is, however, considerable variation in growth rates and the survey, "Newsprint Data: 1960," points out the faster growth which is now occurring overseas than in North America.

In contrast to 1959, demand shows greater increases than capacity in 1960 and world production represents about 88% of capacity compared with 84% last year. Key factors in the outlook for 1961 are the increase of capacity now under construction in Scandinavia and a temporary pause in the United States consumption growth coincident with the current stage of the economic cycle. Their combined effect is such that a world average operating rate of about 86% is suggested for next year.

The survey includes a chart and table of seasonally adjusted United States consumption rates which show a temporary decline starting last June. If maintained it suggests slightly lower consumption in 1961 than the record 7.4 million tons expected for 1960.

A new feature of this survey is a review of United States consumption by areas, showing the faster growth rates of the West and South compared with the Midwest and Northeast. The former are increasing at 3.7 and 3.4% per year, respectively, compared with 1.5 and 0.8 % for the latter areas.

Canadian mills' production for 1960 is expected to show an increase over 1959 of about 341,000 tons of 5.3% and average operating rate for the year will be about 88.5% compared with 85.0 last year. According to the report, "This is the largest annual increase since 1947 and a new production record about 4.1% more than the previous record of 1956."

For 1961, however, a temporary decline of about 2% is suggested, largely because of the indicated cyclical fluctuation in the United States demand. Canadian capacity for 1961 is virtually unchanged and an average operating rate of about 87.1% would result.

The total amount of "stand-by" capacity in Canada for 1961 appears to be almost a million tons, a reduction from the 1958 peak when it was nearly 1,150,000 tons. The report notes that in the future no repetition of the long post-war period of constant operation at full capacity is foreseen. Growth of capacity in Canada and elsewhere is expected to precede anticipated growth of demand, thus maintaining a margin of "stand-by" capacity available in case of need.

*American Pulp and Association, *Monthly Statistical Summary* 38, No. 8, (December, 1960).

The survey includes comparisons of capacity growth in Canada with other areas of the world, showing the greater rates but smaller volume elsewhere. It points out the very rapid increases recently achieved in the United States and Scandinavia, each of which has added about a million tons in the last five years. Also shown are capacity increases by region in Canada and in the United States, emphasizing the greater growth rates of the Canadian West and the Southern States.

As in previous years, this survey presents a complete world statistical review with charts and tables, also individual data country by country. It concludes with a list of new capacity projects and prospects all over the world.

Copies of this report are available from the Newsprint Association of Canada, Sun Life Building, Montreal, Que.

Foreign Plant and Equipment Expenditures by U. S. Manufacturing Companies

Plant and equipment expenditures abroad by U. S. manufacturing companies for paper and allied products, in millions of dollars, by areas, for 1957–60 are as follows:

Year	*All areas*	*Canada*	*Latin America*
1957	144	120	11
1958	192	82	8
1959	90	75	5
1960	78	60	7

	Common market (Europe)	*Other Europe*	*Other areas*
1957	4	4	5
1958	4	5	3
1958	3	4	3
1960	3	5	3

American Society for Metals

Merrill A. Scheil, Director, Metallurgical Research, A. O. Smith Corp., Milwaukee, Wis., has been the elected national secretary of the ASM since Oct. 21, 1960, and will be an officer of the Society in this capacity through October, 1962. For the past two years he has been national trustee, 1958–60 of ASM.

Corn Industries Research Foundation

John T. Goodwin, Jr., technical director of Corn Industries Research Foundation, Inc., of Washington, has been honored by the New York Academy of Sciences with a fellowship in the Academy. This honor is in recognition of Dr. Goodwins' accomplishments in science in his present post and, previously, with the Midwest Research Institute, of Kansas City, where he was engaged in research in silicones. Fellowship in the New York Academy of Sciences is awarded to a member who has attained "outstanding recognition for scientific achievement or for the promotion of science."

Folding Paper Box Assoc. of America

S. Edward Iciek, statistician for the Folding Paper Box Association of America, has been awarded the degree of master of business administration by the University of Chicago.

Since he joined the Association staff in 1956, Iciek has completely reorganized the FPBAA statistical program and has developed timely reports about the folding carton industry. Wide acceptance of these reports has caused the industry to be recognized as an economic barometer of business conditions among consumer nondurable goods.

National Academy of Sciences

The National Academy of Sciences-National Research Council has announced the appointment of Gardner H. Chidester, chief of the Division of Pulp and Paper at the U. S. Forest Products Laboratory, Madison, Wis., as a member of the Academy-Research Council's Committee on Paper Base Materials. Mr. Chidester's special interest has been the development of new techniques for preparing wood pulps. The committee is one of several within an Advisory Board on Quartermaster Research and Development. The Advisory Board is responsible for supplying scientific and technical advice to the Quartermaster Research and Engineering Command, Natick, Mass., on the Command's research and development programs.

National Safety Council

In 1913 a small group of far-seeing men, appalled by the human tragedy of accidents and abhoring their waste in an efficient society, founded the National Safety Council as a membership association.

Privately financed and guided by public-spirited volunteers, it has given force and direction for almost half a century to the solution of one of America's most persistent and destructive social problems.

Around the framework provided by the Council has grown a vast structure of knowledge and method—a virtual science of safety—that has proved its basic premise: Accident Prevention Works.

In the last 10 years alone, the population death rate for all classes of accidents has declined 15%. It is down 30% for home accidents. Occupational deaths per 100,000 workers have dropped 18%. The motor vehicle mileage death rate (deaths per 100 million miles) has improved 28%.

Striking evidence of accomplishment in school programs is found in the death rate for school children, which has dropped 61% since 1922 in the lower elementary age group (5–9) and 43% in the upper elementary group (10–14).

	1959	*1950–59*
The Cost in Lives		
Work	13,800	145,300
Motor vehicle	37,800	375,000
Home	26,000	285,000
Public	16,500	160,000
Total (Totals eliminate duplications)	91,000	934,000
The Cost in Injuries		
All accidents	9,200,000	93,000,0000
The Cost in Dollars		
All accidents	$13,000,000,000	$100,000,000,000

Accidental deaths and the millions of disabling injuries constitute one of the greatest social problems facing the United States. Accidents rank fourth as a cause of death exceeded only by heart disease, cancer, and vascular lesions. They are the greatest killer of children beyond infancy. They are the leading cause of death between ages 1 and 36. Accidents rob the nation of more *working years* than any disease.

Some safety can be imposed through improvement of physical environment, equipment, and laws and regulations. But accidents are chiefly a problem of human motivation and behavior. Unlike some medical problems, no drug or vaccine will one day solve it. The methods to prevent accidents are known, tested, and proved.

The universal recognition and application of these methods —an understanding and acceptance by every individual— are reached only through mass education.

The task ahead is to refine and broaden the techniques of accident prevention so that safety becomes a family affair in every home in America.

During the decade, phenomenal gains have been made in worker safety. Accident frequency rates are down—64% in electrical equipment, 62% in automobile manufacture, 59% in gas utilities, 55% in machinery, 51% in rubber, and 36% in all industry.

Four out of the first five industrial world records were broken in 1960. A new all-time high in no-injury records was reached with 31,628,157 man-hours.

The Council's program for professional motor transportation drivers imposes rigid requirements for earning the Safe Driver Award, yet the number of drivers annually earning the award has grown from 40,000 a decade ago to 175,000 at present. In 1933 the National Fleet Safety Contest enrolled 221 fleets representing 20,000 vehicles. In 1959 a total of 2252 fleets representing 278,114 vehicles achieved a combined accident frequency rate 47% below the 1933 figure.

The Annual Inventory of Traffic Safety Activities, which each year measures and analyzes the effectiveness of state and city traffic accident control, shows steady improvement in program management that has contained the explosion of vehicle ownership and travel. A study of a representative city in each of 10 population groups discloses a 15% improvement in program performance, resulting in a 25% reduction in deaths, during the last five years.

To upgrade the effectiveness of state and local citizen safety organizations, the Council assists them in a continuing inventory and appraisal of their programs and management. Of 1500 recommendations for improvement made to 18 state and 70 metropolitan organizations, 1000 have been put into effect.

Since 1913, the year of the Council's birth, a steadily reduced death rate has brought a saving of over 850,000 lives.

Does such a statistic tell the real story? Behind it is the human story of families free from heartache and debt, of carefree children and secure old age, of efficient production and reduced waste, of a moral concern with individual welfare that is one of the proud traits of the American people.

Packaging Institute

James W. Field formerly with TAPPI (Technical Association of the Pulp and Paper Industry) has joined the staff of the Packaging Institute effective December 1.

Mr. Field will be the Packaging Institute's Technical and Field Service Director supervising the accelerated programs in all areas of the Institute's national technical activities.

A Temple University graduate, Mr. Field served West Virginia Pulp and Paper Co. as a chemist before joining the technical staff of TAPPI.

Mr. Field is a member of TAPPI, Society of Rheology, American Chemical Society, and Paper Industry Management Association.

Overseas

India

U. S. Loan for Indian Firm

The U. S. Government has announced a credit of Rs. 20 millions in Rupees for the Seshasayee Paper and Board Co., Ltd. of Madras State. The loan will be channelled through the U. S. Export-Import Bank and will be used to help finance the construction of a paper mill in Erode. The mill will use both bamboo and bagasse in its processes, and its location in Erode is near the sources of those raw materials. Plant equipment includes two papermaking machines with bleaching and other facilities.

New Paper Plant

The Government of India has issued a license for a Rs. 90-million pulp and paper factory, an Indo-French venture in the private sector.

The French collaborators would participate in the issue capital to the extent of Rs. 5 million, besides providing deferred credit to the extent of Rs. 36.2 millions.

The factory, to be located in North Kanara district, would manufacture 110 tons of dissolving pulp per day from bamboo. The factory is expected to go into production by 1962.

Paper Production

Production of paper and paperboard for the first time exceeded 200,000 tons in 1957, when it amounted to 210,100 tons. In 1958, output rose to 253,100 tons and in 1959 to 294,000 tons. In the first six months of 1960, production amounted to 184,000 tons, which was the same as in the whole of 1955. At this rate, production in the full year 1960 is likely to exceed 300,000 tons.

—India Economic Newsletter

Pulp and Paper Manufacturers and Converters

Allied Paper Corp.

Clayton Russell was today named director of quality control at the Allied Paper Corp. and will assume overall direction of the quality control for the King, Monarch, and Bryant Mill Divisions.

American Can Co.

Delmont J. Lohuis has been named assistant to the vice-president in charge of corporate research, machinery development, and new products at the American Can Co. Formerly director of research of the Canco Division's laboratory at Barrington, Ill., Mr. Lohuis will make his headquarters in New York. In addition to the above duties, he will also assist the vice-president, Research and Development Dept., Canco Div.

Dr. Orval R. Alexander has been appointed Director of Research for the Canco Division. His headquarters will continue to be at Barrington, Ill.

Ralph W. Kaercher was named manager, Paper & Plastics Section, succeeding Dr. Alexander.

Donald W. Riester has been appointed general manager of Canco's Technical Service Division, succeeding D. F. Sampson, retired. Mr. Riester's headquarters will be at Maywood, Ill.

Donald J. Wessel was named manager of the Central Technical Service Laboratory at Maywood, succeeding Mr. Riester.

Bowaters Southern Paper Corp.

George C. Davis, acting chief engineer of Bowaters Engineering and Development Inc., has been appointed chief engineer.

Mr. Davis joined E & D when it was formed in January, 1957, as design engineer. He became acting chief engineer in 1959. He joined the Bowaters organization in 1955 as a design engineer at Bowaters Southern Paper Corp., Calhoun, and later became chief draftsman. Before coming to Bowaters, Mr. Davis was associated with Coats and Clark, Inc., in Albany and Toccoa, Ga., International Paper Co., in Natchez, Miss., and Mobile, Ala., and taught at Miller County, Ga., High School.

George C. Davis, Bowaters Southern Paper Corp.

Bulkley Dunton & Co.

Celebrating his 50th anniversary in the paper business, Phillip C. Batzle attended a luncheon tendered him jointly by the Martin Cantine Co. and Bulkley Dunton & Co., Inc. Mr. Batzle has been with Cantine for the last 20 years. Prior to that he was with Bulkley Dunton for 20 years.

Celgar, Ltd.

Celgar's new bleached kraft pulp mill is nearing completion in British Columbia's colorful Arrow Lakes District, lying in the Columbia River Valley just north of the United States border. Section by section the 500-ton capadity mill is being tuned up and is expected to be producing bleached pulp early in 1961.

Adjacent to the pulp mill and designed to supply it with about 10% of its chip requirements, as well as with hogged fuel for steam production, will be a modern sawmill which next July will begin to produce construction and finished grades of lumber. This combination represents the Province's first integrated forest operation away from the Coastal Region.

The Lower Arrow Lakes is already fringed with storage rafts of bundled pulp logs as the wood supply builds up.

The first units of the Celgar mill to go into operation were the steam plant and woodroom so that chips could be stockpiled prior to the startup of the pulp mill.

The steam requirements of both the sawmill and pulp mill will be supplied by the steam and recovery plant of the pulp mill, utilizing the combined residue from the woodroom and sawmill and the spent liquor from the pulping process. Design material and heat balances indicate an approximate "in balance" situation in respect to auxiliary fuel. An excess of hogged fuel stored in the yard during the summer months will be used to meet increased winter load conditions.

The plant design shows what can be done to minimize capital expenditure without sacrificing operating convenience, material quality, or plant efficiency. The size of the building and the selection and arrangement of the equipment were the determining factors in keeping first costs in line. The building floor area is about 40% less than conventional plants performing the same service. To utilize available space to the best possible advantage and avoid congestion, the location of each piece of equipment has been chosen with care.

Layout was facilitated by the use of a scale model. Preliminary design was checked out on the model with an eye for best location, room for maintenance, operating convenience, and lack of interference with other services. In this way costly field changes were largely avoided, and the additional design effort resulted in a better than average grouping of equipment and controls.

Equipment selection was made on the bases of quality and first cost rather than personal preference. Control items were carefully evaluated and nonessentials were eliminated. In the choice of materials capital outlay was balanced against service life and replacement cost.

Equipment and Services

The services that this plant will provide to the combined operations are: steam for process and heating; water for hydraulic barker operation; air for process and instrumentation; and cooking liquor for the digesters.

Steam Generating Equipment. Two boilers supply the steam requirements. A Foster Wheeler power boiler was designed to generate steam at 600 p.s.i.g., 750°F. superheater outlet temp. from water at 275°F. and produce 285,000 lb. per hr. when fired with mill waste and gas. The unit is designed to operate on mill waste and/or gas with oil as a stand-by fuel. The normal operating load will be 125,000 lb. per hr. on mill waste. Wood waste from the sawmill and woodroom will be pressed, hogged, and supplied to the plant at 55% moisture. An estimated 24,400 lb. per hr. will be available. Excess hogged fuel will be reutrned to the yard storage.

The boiler is equipped with Kent combustion control equipment; control of combustion and feed water is fully automatic. Five variable speed feeders proportion the hogged fuel supply to the pneumatic spreader stokers which distribute the fuel over sloping pinhole grates. Air for wood is damper controlled through four compartments under the grates. The furnace is equipped with eight Peabody ring-type gas burners combined with oil burners, four on each side. Air for combustion is heated in an integral air heater. A multiclone dust collector will reduce the possibility of carbon contamination of the outside chip storage; the fly ash collected is returned to the boiler by a cinder return system. A pneumatic ash disposal sytsem will facilitate removal of ashes from the plant.

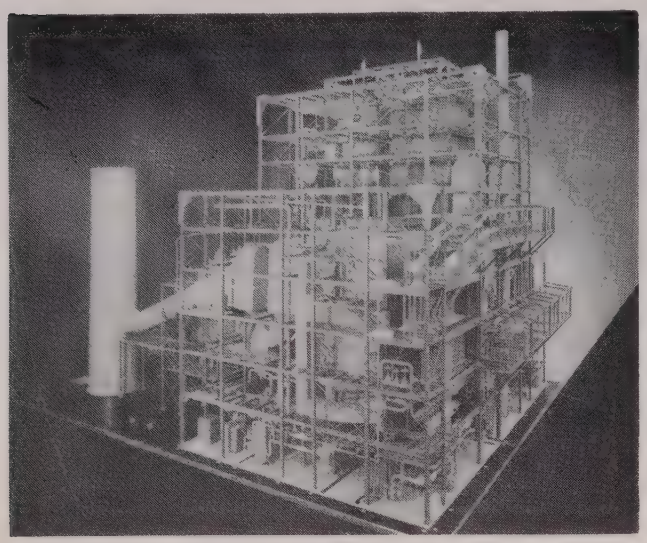
While the main construction project draws to a close and the plant is being tuned up a unit at a time, Celgar's outside chip piles begin to rise on the freshly storage surface. Behind the two silos can be seen the liquor-making system and part of the pulping group buildings. An adjacent sawmill, scheduled to begin operation next July, will supply nearly 10% of the chip requirements. Rafts of bundled logs line the fringes of the Arrow Lakes to insure a ready supply for winter operation

The recovery boiler is a 500-ton per day Combustion Engineering unit originally designed to burn 1,600,000 lb. of solids every 24 hr. After the order was placed, a change was made in the designed arrangement of the heating surface to change the rating to 1,800,000 lb. of dry solids per 24 hr. The boiler is rated at 224,000 lb. steam production, 600 p.s.i. 750°F. superheater outlet temperature when operating at rated tonnage. Combustion Engineering has incorporated the latest innovations in recovery design in this unit. Particular consideration has been given to the arrangement of superheater and screen tube platens, welding of tubes during erection and a change in economizer design to facilitate erection.

Steam for process and heating is supplied to the mill at 175 and 75 p.s.i. Most of this steam will be provided by auxiliary turbine drives operating at 600 p.s.i. and exhausting at either 175 or 75 p.s.i. The balance of the requirements will be provided through reducing stations. Hydro power in the area is available at a mil rate attractive enough to make it uneconomical to use steam to generate electrical power.

Feed Water Supply. Water will be supplied to the boilers through a common feed water system. Ratio of condensate return to make up will be in the order of 60/40. The make-up water originates from the Ranney deep well system that supplies the mill. This water has a total hardness of 100 + p.p.m. and a silica content of 17 p.p.m. making it unsuitable for boiler feed without pretreatment. A Cochrane desilicizer pretreatment plant will condition boiler makeup water.

The plant comprises three cation units; three anion units; brine, caustic, and acid handling and storage equipment; and the necessary controls for automatic operation. The plant is rated for 450 g.p.m. and will reduce the total hardness to 0.2 p.p.m. and the silica to 1.0 p.p.m. Feedwater will be heated in a Graver 500,000 lb. per hr. spray-type



Power boiler in foreground was first of Celgar's units to start up in anticipation of operating the woodroom to stockpile chips. This general view from southwest corner gives a clear picture of the steam and recovery plant layout

deaerating heater designed to operate at 45 p.s.i. Three Klaen-Schanzlin-Becker feedwater pumps will supply water to the boilers. Two of these pumps are turbo-driven 850 g.p.m. units; the other is a motor-driven 500 g.p.m. unit. One of the 850 g.p.m. pumps will supply both boilers under normal load conditions. Each boiler is equipped with a three-element feedwater control system and a main and auxiliary feed line.

Barker Pumps. High pressure water for the two hydraulic barkers in the woodroom is supplied from the steam plant, by 1275 g.p.m. K.S.B. pumps. The two pumps are driven by 1600 hp. Westinghouse turbines. A third unit will be installed at a later date to provide water for a barker in the new sawmill.

Mill Air Supply. Mill and instrument air will be supplied by three Canadian Ingersoll Rand 600 c.f.m., 125 p.s.i. XVHC type air compressors. Two of the compressors are motor driven and the third is turbo driven. An innovation here is the use of aluminum piping for the high pressure air distribution system.

Liquor Supply System. Every precaution has been taken to minimize air and stream pollution. Weak black liquor from storage will be treated in a Lunberg Ahlen B-T Metoder oxidation system before being pumped to the evaporators. The system is made up of two sets of identical equipment: oxidation tower, foam box, cyclone, and blower.

Evaporators. Evaporators are located in the steam and recovery building. They are supplied by Conkey Equipment C. B. & I. manufacture LTV type, six body sextuple effect integral units; rate at 590,000 lb. per hr.—170°F.—15 TS inlet and 170,000 lb. per hr.—188°F.—52% TS outlet, evaporation 420,000 lb. per hr. Steam requirements 81,800 lb per hr. at 40 p.s.i. economy 5.14 lb per evaporator per lb. steam.

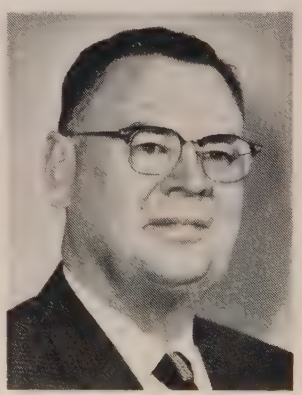
The gases leaving the recovery boiler pass through a Research-Cottrell wet bottom precipitator; a double unit, horizontal gas flow design, rated for 220 c.f.m. gas at 325°F. The precipitator is equipped with opzel collecting plates and loop ring supported, weighted, stainless steel discharge wires. Energy is provided by three 70 kvp., 460 ma. silicon rectifier transformers controlled by the Cottrell automation system. Rappers and controls are provided for the collecting and distributing plates, and a syntron electromatic vibrator system for cleaning the discharge electrodes.

Controls. The controls for the power boiler, the recovery boiler, and the evaporators have been centralized on the operating floor. The three panels will be joined to form one unit. This arrangement will simplify the training of personnel and permit a combining of duties that would not be possible otherwise. The controls for the deep well pumps supplying mill water, and the controls for the black liquor oxidation system will also be incorporated in this common control panel.

Personnel. The operation of the steam, recovery, recausticizing and lime kiln departments will be combined for the purpose of manning and the line of promotion in this area will be progressive through the eight job categories involved. This arrangement is a logical one because of the inter-relationship of the services provided; and it has the added advantage of bringing the certificated steam engineers as a group closer to the pulp production. The high standards set by the B. C. Inspection Department insure a good selection of certificated personnel. The steam and recovery plant will employ six men per shift: a salaried supervising shift engineer with a valid 2nd class B. C. Certificate; a recovery engineer with a valid 3rd class B. C. Certificate; a power boiler engineer with a valid 4th class B. C. Certificate; a 1st assistant recovery evaporator operator; a shift utility man and a 2nd assistant recovery man. Recausticizing will be staffed with two men: a recausticizing operator and a lime kiln operator.

Celotex Corp.

Charles N. Rogers, former head of engineering for the Sonoco Products Co. of Hartsville, S. C., has been appointed director of engineering for The Celotex Corp., according to I. K. Hearn, vice president-operations. The appointment was effective Dec. 1, 1960.



Charles N. Rogers, Celotex Corp.

Mr. Rogers was named to take over the position vacated last April by George H. Burt, who was promoted to technical consultant to the vice-president-operations. The new director of engineering will be in charge of all engineering functions in the corporation, reporting directly to Mr. Hearn. He will headquarter in the firms' general office in Chicago.

Columbia Cellulose Co., Ltd.

Columbia Cellulose Co., Ltd. announces the appointment of Denis J. Rowse to the position of assistant operating superintendent. Previously employed by the International Fisheries Commission and Pacific Fisheries, Ltd., Mr. Rowse joined Columbia Cellulose early in 1951 as a technician in the filter plant. He advanced to the position of chief process engineer prior to his recent promotion. The duties under his new appointment will be to coordinate mill trials and special projects from an operating standpoint and to act as liaison with Technical and Process Engineering Dept.

W. D. Stothert has recently been appointed assistant mill manager at the Prince Rupert high alpha pulp mill of Columbia Cellulose Co., Ltd. He is a graduate in Engineering from the University of Alberta with a Master's Degree from Toronto. He was assistant chief electrical inspector for the Province of Alberta for several years and later was closely

associated with the construction of Canadian Chemical Co.'s plant at Edmonton as chief electrical engineer for Brown & Root, Ltd. Mr. Stothert joined Canadian Chemical in 1953 and moved to Prince Rupert in 1959 as manager of engineering and maintenance.

Continental Can Co.

Continental Can Co.'s new bleached paperboard mill near Augusta, Ga., is now in operation producing linerboard and bleached board.

The mill, part of a 2600-acre complex, is essentially a single $40,000,000 integrated system which eats logs at one end and turns out bleached board at the other end. It will

Continental Can Co.'s new bleached board mill near Augusta, Ga. At right is the Kamyr continuous digester, in center is the pulp mill, and at left is the paper machine building

operate at the rate of 700,000 lb. a day, a rate made necessary by the increasing consumption of bleached sulfate board which Continental executives say will continue to grow at three times the rate of other paperboards. Also known as special food board, it is used for paper tableware, cigarette boxes, cartons for frozen foods and ice cream, baked goods, dairy, meat and dry food products.

Fibreboard Paper Products Corp.

San Joaquin Pulp and Board Mill

Expansion by more than a third of productive capacity at California's only virgin kraft pulp and paperboard mill, the San Joaquin pulp and board mill of Fibreboard Paper Products Corp., is now completed and full production schedules are underway, officials of the company have stated.

The new mill was a project of Bechtel Corp., San Francisco-based international construction firm. Fibreboard awarded the contract for the expansion to Bechtel in May, 1959, and ground was broken for the project almost immediately.

The expansion has added a third paperboard machine, complete with pulp processing system and additional raw material handling equipment, to the original San Joaquin facility, which was built in 1948–49. The new mill was constructed to initially produce 72,000 tons of kraft liner board per year, bringing the total yearly capacity of the plant to over 200,000 tons. Addition of the new capacity makes Fibreboard's shipping container manufacture a fully-integrated operation. Heart of the new facility is a big, 172-in. Black-Clawson fourdrinier paperboard machine. The machine produces kraft liner for use in the company's six Western container manufacturing plants.

Before the new construction, the San Joaquin plant already manufactured corrugating medium for shipping container manufacture as well as bleached kraft paperboard for use in the production of food cartons in the company's six Western carton plants.

An advanced system of air and water effluent controls was engineered by Fibreboard for the third machine.

Raw materials for the installation are similar to those used by original installations at the plant. Principal raw materials are forest and lumber residues and other by-products of California logging operations and sawmills.

Major components of the new construction include chip handling, digestion, chemical recovery, causticizing, pulp washing, and pulp refining facilities to support the no. 3 machines, together with facilities for loading and shipping the finished product.

Several elements of the new project were built to enable the capacity of the machine to be doubled economically in the future. These include a 400-ton Babcock and Wilcox recovery furnace and a 9-ft diameter by 250-ft. long Traylor lime kiln.

The new chip handling facilities provide for improved unloading, outdoor storage by wood specie, as well as added facilities for reclaiming and screening of wood chips. One of the outstanding features of the new chip handling installation is a new Heyl and Patterson car turner capable of unloading up to ten railroad cars per hour. A crew of only two men operates the unloading and controls chip flow to allotted storage aras in an 800 by 200-ft., asphalt-topped storage location east of the car unloading stations. Another technical feature of the new plant is in chip conveying. Chips are conveyed to the manufacturing process by a pneumatic chip handling system. The new system, designed and fabricated by Rader Pneumatics of Portland, Ore., has a capacity of 50 units per hr., with air supplied by a 350-hp. Sutorbuilt heavy duty blower delivering 11,400 c.f.m. at 6 p.s.i. pressure.

A principal component of the new mill is its continuous pulp digester. After screening and blending operations are com-

An elevated structural steel supported belt conveyor discharges wood chips through a chipper onto piles according to species. The motor propelled tripper is operated by remote control

pleted chips are conveyed to the Kamyr continuous digester. The Kamyr is a 100-ft. tall, 5700 cu. ft. installation, the first of its kind used in kraft liner board production in the Western United States.

The new mill also features hot stock screening, a process designed to improve stock washing while also making it more economical. In conventional screening, the pulp from the digester is first washed an then screened. In hot stock or black stock screening the hot pulp in its black liquor is screened

and then washed. The new installation is among the first in U. S. paper mills.

The no. 3 machine, principal component of the new facility, is housed in a building 486 ft. long, constructed of steel with asbestos cement panel walls. The machine itself has a total length of 360 ft. The machine was manufactured by The Black-Clawson Co. in its Watertown, N. Y. plant.

Stock for the machine is refined through two 800-hp. Jones double-D disk refiners and three 400-hp. Jones Majestic jordans. The 172-in. wide by 133 ft. long fourdrinier section of the machine is of the permanent cantilever, quick wire changing type. The primary and secondary airloaded head boxes by Valley Iron Works are designed to operate in a speed range of from 250 to 1500 f.p.m., and to operate on 18 to 90-lb. natural kraft liner board. The fourdrinier section has nine suction boxes, a 28-in. diam. breast roll, and a 40-in. diam. suction couch roll.

Components of the drier section of the machine are 54 paper driers, and four felt driers, all designed for 125 p.s.i.g. steam pressure. The paper driers are 60-in. diam. and 170-in. across.

Following the third drier section, two open calender stacks are located with two 60-in. diam. driers mounted between the stacks. The first stack has eight rolls, the second stack six rolls. A Black-Clawson Auto-Flite super 36-in. reel follows the final calendar stack.

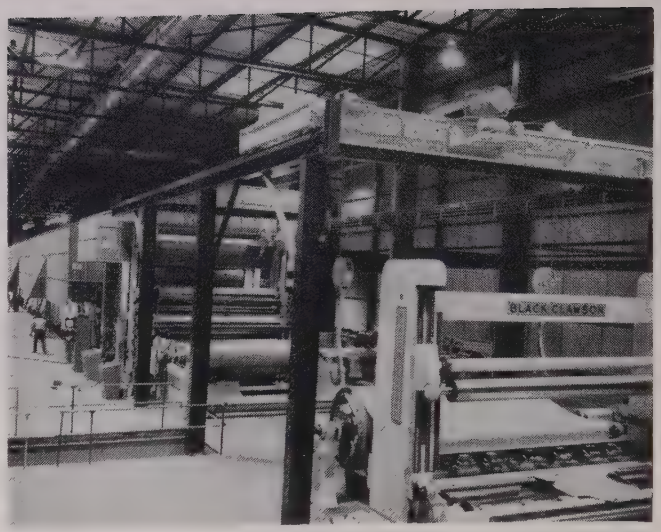
Drew Engineering Co. of Portland, Ore., designed and installed the machine hood and associated air systems. The system consists of a drier hood and a calender hood both fabricated from asbestos cement flat board manufactured by Pabco Building Materials Div. of Fibreboard. The vapor absorption system utilizes both fresh air from the outside and hot air from the hood.

The chemical recovery facilities in the new installation include a sextuple evaporator, recovery furnace, causticizing system, and lime kiln.

The recovery furnace has a capacity of burning 1,245,000 lb. of black liquor solids per day. Designed and built by the Babcock and Wilcox Co., the furnace produces 197,000 lb. of 600 p.s.i.g., 715°F. steam per hour. All of the steam from the recovery furnace is used to operate the new mill.

In keeping with high Fibreboard standards for effluent control, some of the most important components of the new mill are effluent control facilities.

A new dimension has been added to the structural elevation of Fibreboard's San Joaquin pulp and board mill near Antioch, Calif. This is the recovery boiler (left), precipitator, (center), scrubbers, and stack, all components of the new third machine kraft liner operation. The units to the right of the foreground tank are part of the original mill



One of the first rolls of kraft liner board to be manufactured on the new third machine at San Joaquin's pulp and board mill is shown on the winder. The roll is 160 in. wide. It was cut into three sections each weighing more than 3000 lb. The new kraft liner board mill was designed to produce an initial 72,000 tons a year

An electrostatic precipitator designed by Koppers Co. is a prime factor in control of air effluent. The new precipitator is a double chamber, 44 lane, four field, separately energized unit powered by three 700 m.s. double half wave silicon power units. It is constructed of acidproof brick.

In addition to the electrostatic precipitator, two Chemico stack flue gas scrubbers contribute to air effluent control. They are Pease-Anthony type scrubbers, each with a capacity of 78,500 cu ft. of 260°F. flue gases. They are constructed of 316 ELC stainless steel. are 12 ft. diam. and 42 ft. tall.

A principal component of water effluent facilities at the new mill is a saveall which controls the entry of solid content into the water effluent.

Designed and built to achieve maximum quality production, the new mill is completely independent and self-supporting, with all of its own utilities, including water, air, water treatment, power distribution, chip system, chemical recovery system, steam generating capability, shipping facilities, and effluent controls.

W. R. Grace & Co.

The W. R. Grace & Co. subsidiary, Sociedad Agricola Limitaded of Paramonga, Peru, has signed a license to make Clupak extensible paper, it has been announced by G. E. Amerman, president of Clupak, Inc., the licensing and research firm owning the patents and trademarks for the manufacture of the unique paper. This is Clupak, Inc.,'s first South American licensee, bringing to 21 the number of licensees the company has in six different countries.

Bagasse is the primary stock used in Peru for papermaking and is relatively short fibered compared with pine kraft. Clupak, Inc., in its research and development laboratory made experimental trial runs and tests of extensible paper made from bagasse and found that the process added materially to the strength and toughness of bagasse paper.

The extensible device will be installed on the no. 1 machine of Sociedad Agricola in Paramonga. The machine has a wire width of 110 in., and an annual capacity of 15,000 tons. Initial use will be for multiwall sacks, particularly for the shipping of fish meal fertilizer.

International Paper Co.

O. B. Beyer, manager for the last 25 years of International Paper Co.'s mill at Corinth, N. Y., retired Dec. 31, 1960, it was announced by G. H. Rand, vice-president in charge of the

company's Northern Division. It was also announced that Judson Hannigan, Jr., has been named to replace Mr. Beyer as manager of the mill.

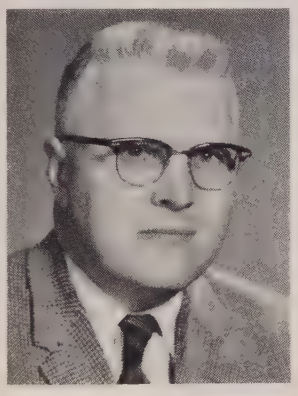
Mr. Beyer, a graduate of Pennsylvania State University, joined the International Paper Co. in 1928, following technical assignments for Canadian Explosives Co. in Montreal, Que., and the Belle Alkali Co. of Charleston, W. Va. His first position was as a chemical engineer at the Cornerbrook, Newfoundland, mill. He moved to International Paper's Hudson River mill at Corinth as a chemist in 1930 and was named assistant manager of the mill in 1932 and, manager in 1935.

A native of Boston, Mass., and a graduate of Dartmouth College, Mr. Hannigan is a veteran of the U. S. Marine Corps. He joined International Paper Co. in 1948 as an assistant chemist at the Hudson River mill. In 1950, he was named a serviceman and two years later, was appointed assistant to the general superintendent. He was named assistant manager of the mill in 1958, which position he has held until his present appointment.

Kimberly-Clark Corp.

Donald H. Grangaard, an authority in lignin chemistry, has been appointed Senior Research Associate by Kimberly-Clark Corp.

Mr. Grangaard, a graduate of the University of North Dakota, and of Ohio State University from which he received his master's and doctor's degrees, has been associated with Kimberly-Clark Corp. since 1939. For two years prior to his entering industrial research, he was research associate in cellulose chemistry at the Massachusetts Institute of Technology. Mr. Grangaard studied at The Institute of Paper Chemistry at Appleton, Wis., in 1953, under a sabbatical leave from Kimberly-Clark. His appointment as senior research associate is the second such appointment made by Kimberly-Clark since establishment of the scientific position. Walter Roehr, an expert in the field of graphic arts, received the first in 1958.



Donald H. Grangaard, Kimberly-Clark Corp.

KVP Sutherland Paper Co.

William I. Roth has been appointed as a research engineer with the Technical Department of the KVP Sutherland Paper Co., KVP Div. Mr. Roth graduated in June, 1960, from the Polytechnic Institute of Brooklyn, Brooklyn, N. Y., with a B.S. degree in chemistry.

Mosinee Paper Mills Co.

Mosinee Paper Mills Co. has announced the promotion of one of its men and the addition of two men to the staff. William W. Smith has been promoted to manager of the eastern sales district. Fred A. Haselow who recently joined the Mosinee staff has been made chief engineer, a new position. Alan R. Bowers has joined the research department staff.

Nashua Corp.

Gibson Greeting Cards, Inc. of Cincinnati, Ohio, and Nashua Corp. of Nashua, N. H., have announced an agreement to form a joint enterprise to be known as GN Papers, Inc. The new corporation, to be equally owned by Gibson and Nashua, will acquire the assets of Nashua Corp.'s Pakay Div., which is engaged in the manufacture and sale of party paper products, such as printed napkins, tablecovers, cups, plates, etc. G N Papers, Inc, will continue to manufacture party paper products.

Nekoosa-Edwards Paper Co.

In a major realignment of production responsibilities, promotions for six men have been announced by Charles H. Reese, manufacturing vice-president of Nekoosa-Edwards Paper Co., a leading producer of business and printing papers.

Arthur A. Bernhardt was advanced to the position of assistant production manager, Wisconsin mills, reporting to Neil Christian, production manager. He will direct the activities of the managers of the firm's two Wisconsin mills and the manager of the production scheduling department.

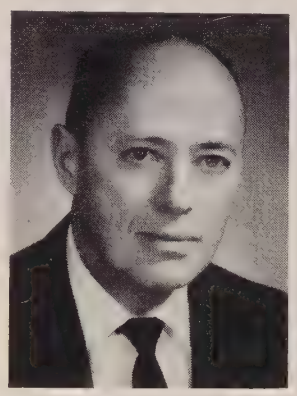
Replacing him as manager of the Nekoosa mill is Patrick J. Hassett. John S. Buchanan was named acting superintendent of the kraft mill at Nekoosa, and Philip Zieman was promoted to general foreman of the kraft mill.

Oxford Paper Co.

Philip L. Hovey, vice-president, manufacturing, announced today the following changes in the management of Oxford mills.

Willis G. Hartford, production manager of the Lawrence Div., will be come mill manager on Feb. 1, 1961, replacing Norman I. Bearse. Mr. Bearse, at his request, will be relieved of the strenuous duties of mill manager and will be assigned to other areas of responsibility in the company.

George E. Prentiss, general superintendent of papermaking at Rumford, is being promoted to the job of production manager at Lawrence to succeed Mr. Hartford and will assume that position on Feb. 1, 1961.



Willis G. Hartford, Oxford Paper Co.

Chester N. Stupp, Oxford Paper Co.

Chester N. Stupp, direct sales manager, will be transferred to West Carrollton effective Jan. 1, 1961, where he will take over the position of mill manager, replacing Charles H. Claypool. Mr. Claypool has resigned from Oxford to accept an important position with Nova Scotia Pulp, Ltd.

John C. Bloom, assistant supervisor, North Div., Uncoated Mill, Rumford, will be transferred to the New York office Jan. 1, 1961, to become a staff assistant, manufacturing, along with William V. Hanson, reporting to Joseph R. Carney, staff production manager.

Paterson Parchment Paper Co.

I. M. Levitt, director of the Fels Planetarium, Philadelphia, and internationally known astronomer, has predicted that 75 years from now, in the year 2035, paper will be a luxury to space travelers and those human beings living on the moon.

"Try to picture yourself in a world where there is little or no paper. Think of trying to send messages without paper or working out some problem in this world where scratch pads are at a premium. Then you will realize how important to our life and our being paper has become."

Speaking recently at a ceremonial time capsule burial at

I. M. Levitt (left), director of the Franklin Institute's Fels Planetarium, places a copy of his predictions for the year 2035 in a time capsule held by E. R. Leonhard, president of the Paterson Parchment Paper Co., at a ceremonial burial of the stainless steel cylinder on the company grounds in Bristol, Pa. The time capsule, which also contained scientific objects and memorabilia from the company's history, will be unearthed 75 years from now

the Paterson Parchment Paper Co., Bristol, Pa., marking the company's 75th anniversary, Dr. Levitt said that because of the atmospheric and geological conditions on the moon and elsewhere in space, "the effort to make paper will tax our resources and ingenuity."

"By 2035, the thing we will have most of and at the least cost will be energy. With this energy we can break, crush, and bake the rocks of the moon to extract the water of crystallization. We will then electrolyze the water and break it into oxygen and hydrogen. Then we will be able to grow plants and vegetables hydroponically," asid Dr. Levitt.

He added, however, that for paper, cellulose is needed and this will be an expensive item to grow in outer space in terms of material and energy. It may be necessary for the paper industry on earth to export this "necessary luxury" to the space dweller, he said.

A microfilm record of Dr. Levitt's predictions together with documents and memorabilia from the Paterson Parchment Paper Co.'s history were placed in an air-tight, stainless steel cylinder.

Also sealed in the time capsule, which is to be unearthed and opened on Paterson's 150th anniversary in 2035, were a number of scientific objects recently developed in the laboratories of the Franklin Institute, in Philadelphia.

E. R. Leonhard, president of the company, gave a brief address before invited guests and Paterson employees attending the historic event. The ceremony was tape recorded and the recording was later placed in the capsule.

Mr. Leonhard said the event was being recorded "so our grandchildren and great-grandchildren who open this capsule three quarters of a century from now will know what Paterson is doing for them today."

Riegel Paper Corp.

The Specialty Products Div. of Riegal Paper Corp. has announced the realignment of operating personnel in its four mills in New Jersey. Lamar A. Moss, formerly manager of manufacturing services has been named technical director replacing Donald G. Magill. Mr. Magill has assumed the vacant position of Upper Mills manager. Both Messrs. Moss and Magill will report to W. Allen Schenck, manager of New Jersey operations. Mr. Moss who, secured his doctorate from The Paper Institute of Chemistry, will devote his full attention to research and development, while Mr. Magill will supervise paper production at Riegel's Warren Glen, Riegelsville and Hughesville mills. Lawrence N. Agnew, formerly superintendent, was named production manager of the Milford mill.

Donald Newcomb was transferred from superintendent of Hughesville mill to superintendent of Coating Dept. at Milford. Richard W. Flores, formerly acting superintendent of Riegelsville mill, was appointed Upper Mills technical superintendent. James Galloway, previously superintendent of finishing at Milford, was named superintendent of Riegelsville, and Joseph Judge was promoted from assistant to superintendent of Hughesville replacing Mr. Newcomb. Thomas Rutt continues as superintendent at Warren Glen mill.

Other changes announced include the transfer of Wolfgang O. Wilfert from superintendent coating to superintendent of converting. He replaces William Anderson who fills a new position of director of Converting Development. Lawrence L. Schroth assumes Mr. Galloway's position of superintendent of Milford finishing.

St. Croix Paper Co.

The St. Croix Paper Co. of Woodland, Me., has announced the promotion of Everett P. Ingalls, Jr., from production manager to the newly-created post of director of technical services.

The position of director of technical services was created as a step in St. Croix's development program. Serving as liason between the woodlands, manufacturing, and sales departments, Ingalls will report directly to the president. As director of Technical Services, Ingalls will provide St. Croix customers with technical advice, market research, and new product information.

St. Regis Paper Co.

Multiwall Bag Technical Seminar

Multiwall bag manufacturers from Belgium, West Germany, Holland, Austria, and Canada recently took part in a

European and Canadian associates of St. Regis Paper Co. recently visited several field installations of St. Regis packing machinery while attending the company's two-week technical seminar. Here they are shown visiting Monsanto Chemical Co.'s Springfield, Mass., plant

two-week technical seminar at St. Regis Paper Co.'s engineering and machine division in East Providence, R. I.

The seminar, which commenced October 3rd, was under the direction of John A. Dyker, international liaison engineer at the East Providence plant.

The European and Canadian visitors, who are international associates of St. Regis, studied research and development phases of packaging machinery manufacture and saw in operation the latest St. Regis packing and weighing machines.

Following their visit to East Providence, the group visited field installations at Buffalo, Minneapolis, Des Moines, Springfield, Mass., and New York.

Staff

Alfred E. Beecher has joined the Research and Development Dept. of the St. Regis Paper Co. as a research engineer. He will be located in the engineering physics laboratories at East Providence, R. I. As a part of the company's overall research program, he will carry on fundamental studies of dynamics and control and applied studies of instrumentation in the fields of pulp production, papermaking, and converting.

Other professional personnel have been added to the St. Regis research and development organization at Carthage, N. Y., and Deferiet, N. Y.

Obie C. Burt, Jr., has joined the coating development group at Carthage, N. Y. Mr. Burt had been a chemist with the Lily Tulip Cup Corp.

Robert M. Benjamin has joined the pulping development group at Deferiet, N. Y. He had previously been associated with Bathurst Power & Paper Co.

Edward R. Hoffman has been named supervisor of statistical services at Carthage, N. Y. He had been chief statistician with Oxford Paper Co., Rumford, Me, and had previously done physical research and quality control work with Hammermill Paper Co.

Maynard C. Nieboer has joined the coating research group at Carthage, N. Y. He had been a research chemist with the Mead Corp., Chillicothe, Ohio.

Scott Paper Co.

Scott Paper Co. Fellowship Awards

Celebrating the 50th anniversary of its Chester plant, Scott Paper Co. has announced the establishment of a Scott Paper Co. Fellowship Award for teachers of social science in the public high schools of Delaware County, Pa.

According to Thomas B. McCabe, president, "The purpose of this award is to stimulate high school teachers of history, government, civics and economics, to earn post-baccalaureate degrees and thereby improve their capacity to prepare students for the responsibilities of citizenship in a changing society."

The awards, two of which are to be granted each year for a four-year period, provide grants-in-aid of $600 per year for four consecutive summers during which the recipient pursues his postgraduate studies. In addition, each award winner is offered up to 6 weeks optional summer employment at the company's Chester plant or at its future administrative headquarters adjacent to the Philadelphia international airport.

To qualify for the award, an applicant must be a junior or senior high school teacher in Delaware County, Pa., and must hold a bachelor's degree from an accredited institution.

Preliminary selections of candidates for the award will be made by the individual senior and junior high schools participating in the program. Each school will select two staff members, who with the system's chief administrator will comprise a Scott Award Selection Committee. This committee will then select from the eligible teachers within the school system one candidate for consideration by the Educational Service Bureau of the University of Pennsylvania School of Education, which shall make the final selection of the winners.

Commenting on the establishment of the awards, Mr. McCabe pointed out that this was another example of Scott's expanding program of aid to education.

"We believe," he stated, "that industry has just as important a role to play in assistance to the social sciences as has in the realm of atomic energy, chemistry and the other physical sciences. By a defined program of assistance to the men and women teaching the humanities we also help the students approach a better understanding of human relationships in our complex world of today."

Staff

Scott Paper Co. has announced the promotions of four men to newly-created positions at Scott plants in Marinette and Oconto Falls, Wis., and in Fort Edward, N. Y.

D. J. Dughie, currently plant manager at Marinette, will assume the new title of gdneral manager, Wisconsin mills. In his new post, Mr. Dughie will assume the additional responsibility of overseeing operations at the Oconto Falls plant. He joined the company in 1939 as a member of the consumers representative department. He subsequently served in a variety of managerial assignments of increasing significance at Scott plants in Pennsylvania, Wisconsin, and New York.

Walter C. Miller will replace William J. Gehlen as plant manager at Fort Edward, N. Y. Mr. Miller is currently plant manager at Oconto Falls. He joined the company in 1948 as an engineer with Coos Bay Pulp Corp., a Scott subsidiary.

Robert W. Johnson has been promoted to the newly-created post of general superintendent at Oconto Falls. He is currently serving as purchasing agent and traffic manager at that plant. He joined Falls Paper & Power Co. in 1938. In his new position, Mr. Johnson will serve as operating head of the Oconto Falls pllnt and will report to D. J. Dughie. He has served in a variety of management functions.

Armand M. Giguere, currently production manager at Marinette, has beed named general superintendent at Marinette. He joined Scott in 1948 as plant engineer at the Fort Edward plant. In 1952 he was named to a similar post at the company's Marinette installation, and in 1957 he was promoted to his most recent post as production manager at Marinette.

William J. Gehlen has been named manager of Scott Paper Co.'s largest plant, which is located in Chester, Pa. Mr. Gehlen, 41, has been manager of Scott's Fort Edward, N. Y., operations since 1958. He will replace Robert I. Thieme, who has been named Scott's vice-president for manufacturing operations.

Strathmore Paper Co.

Henry D. Johnston, vice-president since 1957 and a member of the board of directors since 1951, has been elected president of the Strathmore Paper Co. Mr. Johnston, who has been with the 1000-employee, four-mill papermaking company for 33 years, succeeds F. Nelson Bridgham, who has been serving as president and chairman of the board. Mr. Bridgham, veteran of half a century with Strathmore, will continue as chairman of the board.

Also announced was the promotion of Bemis P. Wood from general superintendent to vice-president in charge of production. He succeeds Laurence W. Shattuck, who has retired as vice-president in charge of production and a member of the board of directors.

Weyerhaeuser Co.

Weyerhaeuser Co. has announced it will build a plant in Alabama's Muscle Shoals area next year for the manufacture of corrugated shipping containers. Construction at Florence, Ala., is expected to be started about April 1 and completed

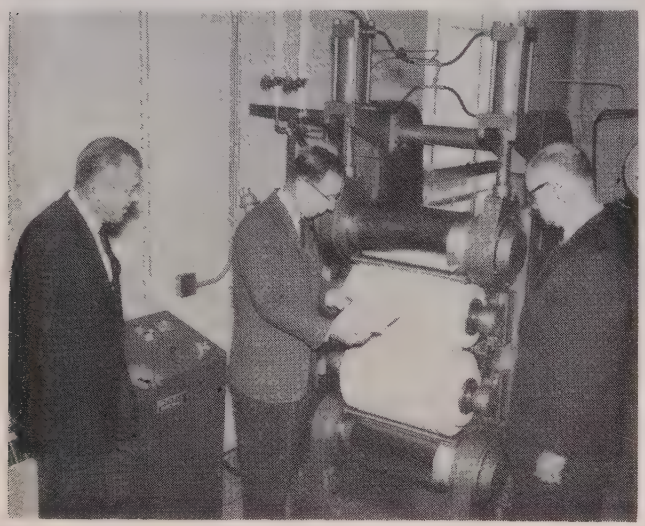
in the fall of 1961. Operations with a initial floor space of 57,000 sq. ft. will require about 30 employees.

W. G. Karran, former general manager of the Chattanooga, Tenn., plant of Container Corp. of America, was named resident manager.

Educational Institutions

The Institute of Paper Chemistry

A new laboratory supercalender has been designed, constructed, and placed in operation in The Institute of Paper Chemistry laboratories in Appleton, Wis. Equipment of a new design was developed as a result of the Institute's desire for a laboratory unit versatile enough to meet the needs of their varied research programs. Working with Institute personnel, Hertel Machine Co. of Menasha, Wis., designed and built this laboratory calender as a prototype.



New laboratory supercalender at The Institute of Paper Industry is examined by Edward A. Hertel, Hertel Machine Co., Menasha, Wis., and C. L. Garey and T. A. Howells, The Institute of Paper Chemistry

This cooperative effort resulted in a supercalender with an open face design to permit easy changing of roll arrangements and with dimensions adequate for four-roll operation. The initial arrangement of the supercalender consists of chilled iron top and bottom rolls of 10-in. diam. and intermediate filled rolls witn 12 and 14-in. diam. Both chilled iron rolls are bored and provided with rotary joints for heating and cooling. This roll combination permits immediate use of two different roll ratios. One filled-to-iron nip probably will be kept constant for "standard" finishing of coated papers in the Institute's research and development program on pigment coating. The other filled-to-iron nip would be available for other trials on roll finish, roll diameter ratios, filling materials, and similar variables. Initial filling materials were provided by Fox River Paper Corp.

Other features of design include a 15-in. face to accommodate coatings from the Institute's 12-in. experimental coater and an hydraulic system for operation at roll loadings up to 3000 lb. per lineal in. Although initial operation will be limited to sheet treatment at slow speeds, bearings and other features of the machine are designed for ultimate operation at speeds up to 2000 f.p.m. feet per minute.

Manchester College of Science and Technology

A summer school on paper and board as packaging materials will be held at the Manchester College of Science and Technology, Manchester, England commencing on Monday, June 26, and ending on Friday, June 30, 1961.

The course is designed for technologists engaged in production, control, research, and development work in the industries concerned with the manufacture of paper and board and of packages and in the use of packages and packaging applications. The lectures are intended to form a post-graduate course and it will be assumed that those attending have reached a standard equivalent to Higher National Certificate in one or more science subjects. Some knowledge of paper and board manufacture and of package manufacture is also desirable.

Visits to both paper and board and package manufacturers and users will be included in the program and opportunities for both formal and informal discussions and social meetings will be arranged during the course. Accomodation will be available in the University Halls of Residence. The lectures will be given in the College of Science and Technology.

Leaflets giving full details of the course and including an application form will be available from the Registrar of the College after Feb. 1, 1961.

The scholarship committee of the University of Maine Pulp and Paper Foundation honored 24 recipients of grants amounting to $37,100 for students in the fifth year pulp and paper program, and 34 recipients of undergraduate scholarships totaling $17,200 at a dinner in November. At the head table, left to right, were: Prof. Lyle C. Jenness, head of the Chemical Engineering Dept.; John D. Cowan, executive vice-president of West Virginia Pulp and Paper Co. and chairman of the University of Maine Pulp and Paper Foundation Scholarship Committee; Alfred H. Nissan, Rensselaer Polytechnical Institute, speaker; Dean Weston S. Evans, dean of College of Technology and toastmaster; Manuel C. McDonald, president of the Great Northern Paper Co., and vice-president of the University of Maine Pulp and Paper Foundation; Lloyd H. Elliott, president of the University of Maine; James A. Gannett, retiring secretary of the University of Maine Pulp and Paper Foundation; and Charles E. Crossland, executive secretary of the University of Maine Pulp and Paper Foundation

Syracuse

Louis Calder Foundation

The State University College of Forestry at Syracuse University has received a gift of $25,000 from The Louis Calder Foundation, New York City, for graduate fellowships in pulp and paper technology, it was announced by Prof. Fredrick W. O'Neil, chairman of the college's Pulp and Paper Technology Department.

The financial stipends, to be designated as the Louis Calder Fellowships in Pulp and Paper Technology, will be awarded annually on the basis of merit, ability, and need, according to Prof. O'Neil.

In making the announcement, Prof. O'Neill expressed the appreciation of the College of Forestry for having been selected as the recipient of the $25,000 gift.

"As a result of the generosity of The Louis Calder Foundation," Prof. O'Neil added, "more young college men who are qualified will now be provided with the opportunity to go on to graduate study in pulp and paper.

"In addition, the College of Forestry will be able to offer the pulp and paper industry of America an increasing number of better-trained personnel—men well qualified by training and experience to handle difficult problems in the processing and manufacture of pulp and paper products. . . to take positions as research chemists in the development of new processes and products in the paper and chemical industries. . .to become technical service representatives or sales engineers for paper or allied industrial concerns.

"For these reasons, we express our sincere appreciation and gratitude to The Louis Calder Foundation for helping to make all this possible," Prof. O'Neil concluded.

The motto of the College of Forestry, now celebrating its golden anniversary is: "Let Each One Become All He Is Capable of Being."

Awards to Staff

Two faculty members of the State University College of Forestry at Syracuse University have been individually honored by The New York Academy of Science with the award of fellowship status in the academy, it was announced today.

They are: Dr. Jan J. Hermans, professor of cellulose chemistry and director, Cellulose Research Institute; and Dr. Vivian T. Stannett, professor of polymer chemistry, Department of Forest Chemistry.

Both men are being honored for their achievements in the field of science. Certificates designating their awards or fellows have been granted to both scientists.

Fellowship in The New York Academy of Science is awarded to individuals who have obtained outstanding recognition for scientific achievements or for the promotion of science.

Washington

Institute of Forest Products

Dr. Donald H. Clark, who has served as assistant technical director of the Institute of Forest Products, retired as of October 1st and now is busy as a forest products consultant in Seattle.

The Institute of Forest Products originally was created by the State Legislature in 1947 as a division of the Department of Conservation. While the Institute's headquarters were in Olympia, its working office was located in the University's College of Forestry Building, Anderson Hall, where advantage could be taken of the University faculty, staff, and research facilities. In 1959 the Legislature transferred responsibility for the Institute to the University and Dean Gordon D. Marckworth undertook directorship of the Institute. Since that time the University has been developing plans for the expanded Institute so that the tempo of present teaching and research can be substantially increased and supplemented by other studies in related fields.

On October 15 the University of Washington Board of Regents appointed Dr. Ben S. Bryant as the new director of the Institute of Forest Products. A graduate of the University of Washington with the degrees of B.S. and M.S. in Forestry (chemistry minor), Bryant took his doctorate in the area of chemically modified wood at Yale University's School of Forestry. He assumed his new duties after 10 years of teaching, research, product development, and consulting activities in the forest products field. He will continue to teach on a part-time basis as Associate Professor of Forest Products. In experience Bryant's background covers a wide spectrum of work on both mechanical and chemical problems. It includes research in the plywood field, the modification of wood with synthetic resins for the furniture industry, adhesives research, the application of statistical methods to forest products research, and the application of statistical quality control in the forest products industry. He has made economic studies of the forest resources and industry from California through British Columbia. He is also a specialist in processes and products of his own which relate to a more profitable utilization of pulp, veneer, plywood, and lumber. At the College of Forestry, Bryant's graduate students are conducting research in the areas of plywood and gluing technology and mechanical pulping.

Commensurate with the University's new organization and purpose for the Institute of Forest Products, Dr. Joseph L. McCarthy, Professor of Chemical Engineering and Dean of the Graduate School, has been named director of the seminar for the Institute of Forest Products. Dr. McCarthy received his doctorate degree from McGill University and was for a time with what is now the Pulp and Research Institute of Canada. He later served as Director of Research of Frasier Companies Limited, a pulp, paper, and forest products company situated in New Brunswick, Canada. At the University of Washington, McCarthy has taught and conducted research in chemical engineering and chemistry, specializing in studies on lignin, cellulose, and pulp and paper problems. For the last 14 years he has been Principal Investigator of the Pulp Mills Research Project sponsored by the Northwest Pulp and Paper Association. More than one hundred technical papers and reports have come from this work and many University graduate students and faculty have participated in it. His responsibilities with the Pulp Mills Research project will continue.

To aid in conducting the Institute Program of research coordination and seminars, Dr. Siegfried Schubert has been appointed assistant to the director. Dr. Schubert was born in Germany, received his undergraduate degree from the University of Munich. He worked for several years in the South Germany wood sugar plant. After coming to the United States he studied at Marquette University in Milwaukee and was awarded his M.S. degree with thesis on hemicelluloses. He has just completed his Ph.D. in organic chemistry at the University of Washington where he worked on the chemical structure of lignin. He was the Hooker Electrochemical Co. Research Fellow at the University of Washington.

Western Michigan

Dr. Alfred H. Nadelman, head of the paper technology department at Western Michigan University, has submitted his resignation at the close of the present semester in January, 1961.

Dr. Nadelman came to Western Michigan in 1948 to direct the new pulp and paper program, then a part of the chemistry department. Under his guidance the program has grown to more than 100 students with its own building, fine equipment, and a full time faculty of five persons. It has also gained departmental status in 1955.

A native of Stettin, Germany, Dr. Nadelman came to the United States in 1938 and was employed as chief chemist by Milprint, Ind., Milwaukee; as chief research chemist by Glassine Paper Co., Philadelphia, and as technical superintendent by International Paper Co., Niagara Falls, N. Y., before joining the WMU faculty.

Internationally recognized for his technical knowledge in the paper industry, Dr. Nadalman has in recent years been called upon to serve as a consultant to paper mills and their suppliers in the United States, Europe, and Asia.

In February of last year he was elected to a 3-year term on the Executive Committee of the Technical Association of the Paper Industry.

He has written numerous scientific articles and technical papers, and has also guided many of his students into publishing papers. He is co-editor of a textbook on converting of paper and paperboard.

During his career at Western, Dr. Nadelman has established

an enviable program academically, while at the same time building a physical plant unequalled for undergraduate training of paper technologists. He has also actively worked in the development of an adult education program for the paper industry which has attracted participants far beyond the limits of Southwestern Michigan.

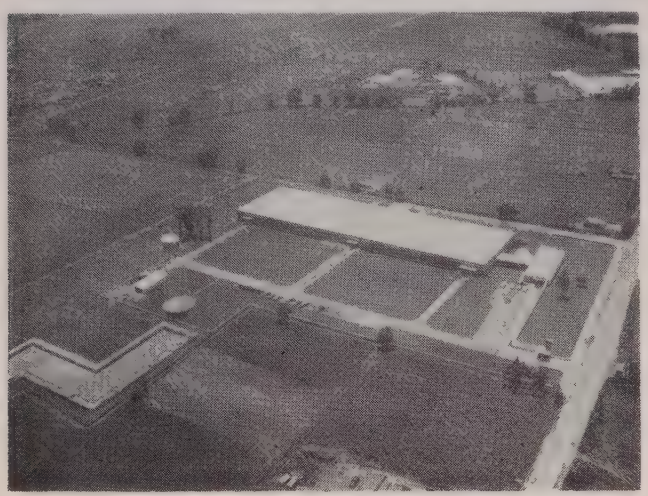
No successor has yet been named.

Industry Suppliers

Albany Felt Co.

Experienced feltmakers have been named to key posts in the newly dedicated Albany-Nordiska de Mexico, S. A. de de C. V. paper machine felt plant near Mexico City.

The $2,000,000 facility, which is already producing felts for the Mexican paper industry, is owned jointly by Albany



Aerial view of new Albany Nordiska de Mexico felt plant near Cuautitlan, Mexico. The 2 million dollar facility is Mexico's first paper machine felt mill

Felt Co., Albany, N. Y., and Nordiska Maskinfilt Aktiebolaget of Halmstad, Sweden. Albany is the major investor.

Formal dedication ceremonies were held on November 11 at the plant's site, on the edge of the town of Cuautitlan, 20 miles northeast of Mexico City.

Overall direction of the plant is under J. Spencer Standish, vice-president of Albany's foreign operations, who is also executive vice-president of Albany's Cowansville, Que., plant.

Ralph B. Wood is treasurer and general manager. Mr. Wood is a graduate of Rensselaer Polytechnic Institute and has had 27 years of experience in various capacities with the present company.

Robert G. Hitchcock, a former superintendent at Albany, is superintendent of Mexican manufacturing operations.

The plant, according to John C. Standish, president of Albany Felt Co., will make felts in size and quantity to meet any foreseeable needs for the Latin American trade.

Mexican paper production, which has expanded tremendously in the past few years in all types of paper and paperboard, is still expanding at a rapid rate. All manufacturing processes from selection of wool through finishing operations will be handled. The mill is equipped with modern machines from the United States, Canada, Sweden, Switzerland, West Germany, and Mexico.

Allied Chemical Corp.

National Aniline Div.

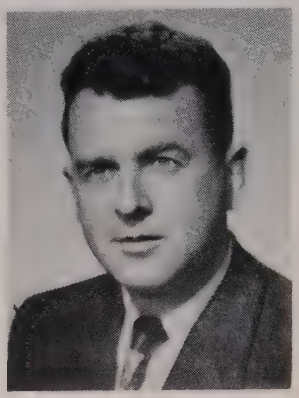
Neal M. Draper has been appointed vice-president of Allied Chemical's National Aniline Division. In his new position, Mr. Draper will be responsible for the sale of National Aniline organic chemicals, and dyestuffs and pigments.

Beloit Iron Works

E. J. Justus, vice-president in charge of Research and Development, Beloit Iron Works, Beloit, Wis., has announced the following appointments.

J. P. Brezinski has been appointed director of paper process

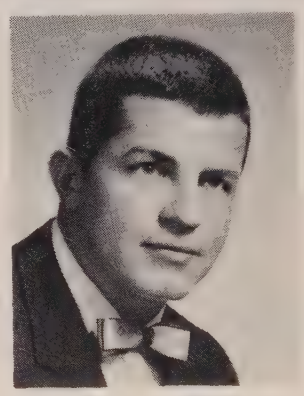
J. P. Brezinski, Beloit Iron Works



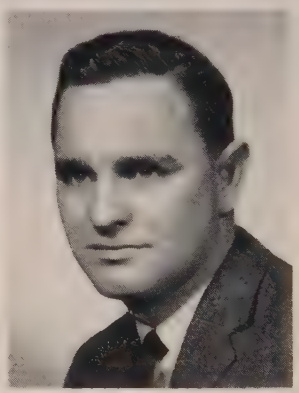
C. B. Dahl, Beloit Iron Works

research. C. B. Dahl has been named director of the Mechanical Experimental Department. Joseph D. Parker will serve as senior research associate and Ralph P. Mahoney has been designated supervisor of coating development.

Mr. Justus pointed out that these appointments have been



Joseph D. Parker, Beloit Iron Works



Ralph P. Mahoney, Beloit Iron Works

brought about by the dramatic expansion of Beloit's research program. He also mentioned that Beloit's new 45,000 sq. ft. Research and Development Center will be completed during the first quarter of 1961.

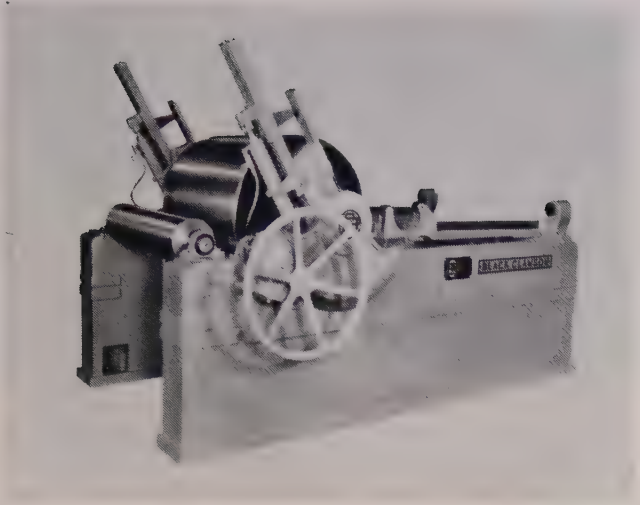
Black-Clawson

Surfastart 1000 Horizontal Reel

A new, compact, easy-to-operate horizontal reel has been developed by the Dilts Division of The Black-Clawson Co., Fulton, N. Y. This reel, the Surfastart 1000, is sized and priced especially for machines up to 100 in trim and operating at speeds up to 1000 f.p.m. with operating roll diameters of 48, 60, and 72-in. The Surfastart 1000 features primary arm loading, synchronized and retractable secondary slides, and antifriction bearings. Unique engaging blocks support the spool and permit smooth engagement of spool to drum. A full line of accessories is available, including motorized primary arms, spreader bar, center wind attachment, core winding, a slitting attachment.

Vokes Rotor

A new Hydrapulper rotor which doubles defibering efficiency was announced recently by The Black-Clawson Co., Shartle Div., Middletown, Ohio.



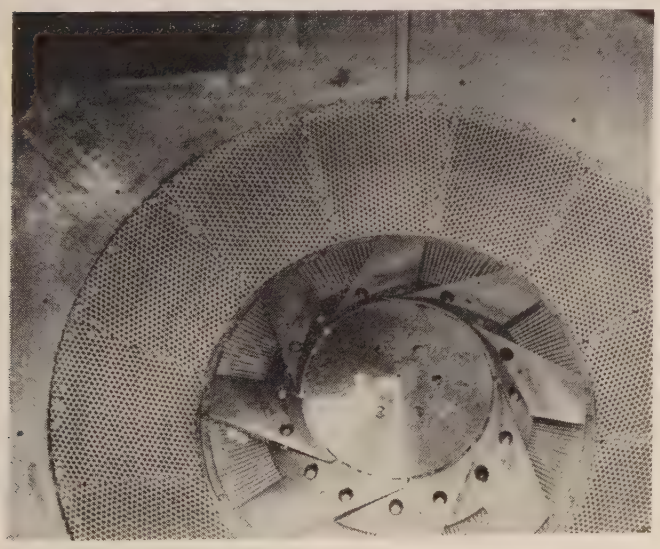
Black-Clawson Surfastart 1000 horizontal reel

The Vokes rotor is the culmination of a carefully planned research and development project carried out over the past several years involving exhaustive tests of rotors, vanes, extraction plates, and bedplates. Well over one hundred tests runs of the final design were made before the design was accepted and released by research.

The Vokes rotor provides optimum performance for split rolls, slab, sheet-trim broke, bale and bulk furnishes, wet strength, as well as in blending mixing. A full consistency range provides for batch or continuous operation. Extraction and dump openings are absolutely nonplugging. It may be purchased as standard equipment for all new Black-Clawson Hydrapulpers, and is also available as a conversion unit for some existing models.

Aetna-Standard Extruder

The Black-Clawson Co., manufacturer of paper and plastics converting machinery and pulp and paper mill equipment, has acquired the plastic extruder business of the Aetna-Standard Div. of Blaw-Knox Co., Pittsburgh, Pa. The signing of an agreement between the two companies was announced today by Frank T. Peterson, president of Black-Clawson. Hale and Kullgren, Inc., Akron, Ohio, engineering and sales service company for Aetna-Standard equipment under Blaw-Knox, continues to serve in a similar capacity with The Black-Clawson Co.



Vokes rotor installed in 14-ft. diam. batch Hydrapulper

Aetna-Standard high pressure extruders compliment the established line of paper and plastics converting equipment of Black-Clawson's Dilts Division, Fulton, N. Y. The engineering, manufacture, and sales of Aetna-Standard extruders will be conducted by the newly formed Hale and Kullgren Plastics Dept. of the Dilts Div., under the direction of Division General Manager, Richard W. Phelps.

Mr. Phelps has announced the appointment of J. Walter Couture, former new products sales director with the Dilts Div., as manager of the new department, which has established headquarters in Akron, Ohio. Mr. Couture will supervise the engineering services to be supplied under contract by Hale and Kullgren, Inc. and will direct the marketing and servicing of Aetna-Standard extruders.

Aetna-Standard extruders are custom made, high-pressure, induction-heated units built in sizes ranging from $1^1/_2$ to 12 in. for various plastic laminating procedures. They are also available in larger sizes for original processing of pure plastics, especially in the polyethylene resin field.

Complete plastics processing lines, in addition to the extruder unit, also require cooling drums, slitters, winders, and other web handling equipment, all of which are regular products in the Dilts Division machinery line of The Black-Clawson Co. The establishment of the Aetna-Standard extruder as a Dilts product creates for the first time a single source of equipment for plastics products manufacturing. Black-Clawson now offers the plastic industry the benefit of undivided responsibility in the supply of new production equipment.

Ciba Co., Inc.

Allen M. Mulder has joined CIBA Co., Inc. as a sales representative in the company's midwestern district office it was announced by William H. Kieffer, general sales manager.

Allen M. Mulder, Ciba Co., Inc.

Mr. Mulder will sell CIBA dyes and chemical specialties to the paper industry in the Michigan area. Prior to joining CIBA Co., Mr. Mulder was associated with Allied Paper Corp. as a mill manager. He has also worked as plant manager for Industrial Container and Paper Corp., production supervisor for Sherman Paper Products, and assistant to the manager of the St. Regis Paper Co., plant in Kalamazoo.

Columbia-Southern Chemical Corp.

Columbia-Southern Chemical Corp., a wholly-owned subsidiary, became a division of Pittsburgh Plate Glass Co. on Jan. 1, 1961. The new division will operate under the name of Pittsburgh Plate Glass Co., Chemical Div. The principal officers of Columbia-Southern Chemical Corp. have been elected as officers of Pittsburgh Plate Glass Co., effective Jan. 1, 1961. On that date, Josepn A. Neubauer became vice-president and general manager, Chemical Div., and Chris F. Bingham became vice-president-Chemical Sales.

General Aniline & Film Corp.

Antara Chemical

Antara Chemicals, a Division of General Aniline & Film Corp., has published a ready-reference data sheet on all of the company's commercially available high-pressure acetylene derivatives. Each of these products, which include PVP, PVP/VA copolymers, PVP-iodine, vinylpyrrolidone, methylpyrrolidone, 2-pyrrolidone, butyrolactone, 1,4 butane-

diol, butenediol, butynediol, and propargyl alcohol, and halides, are described in considerable detail. Chemical structures, physical forms, and descriptions are given, as well as a listing of properties and uses.

Copies of the data sheet, No. AP-60-3, may be obtained by writing to the Acetylene Chemicals Dept., Antara Chemicals, a Div. of General Aniline & Film Corp., 435 Hudson St., New York 14, N. Y.

Staff

Raymond L. Mayhew has been named to the position of manager-technical Service and Development at Antara Chemicals, General Aniline & Film Corp., 435 Hudson St., N. Y., N. Y. Mr. Mayhew's assignment is a new position within the recently changed structure of GAF's Chemicals Group (formerly the Dyestuff and Chemical Division).

Darling & Co.

Nelson Morris II has been elected president of Darling & Co., one of the country's largest independent rendering firms. He succeeds William H. McCausland, who has become chairman of the board. Mr. Morris joined the firm in 1946. He was general manager of the Buffalo, N. Y., plant from 1952 to 1954 and then returned to Darling's Chicago headquarters as assistant to the vice-president in charge of sales. He has been vice-president in charge of sales for the past 4 years.

Foxboro Co.

To coordinate its worldwide sales activities in light of a growing volume of instrument sales, The Foxboro Co. of Foxboro, Mass., has added a marketing division which will serve its associated companies in England, Canada, Holland, and Japan, as well as its U. S. market, according to an announcement by R. A. Bristol, executive vice-president and director of sales.

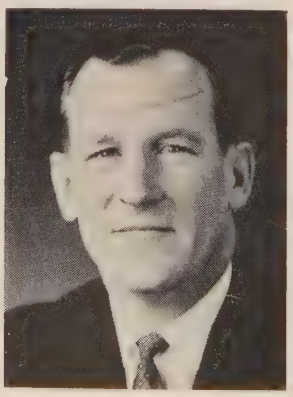
Appointed vice-president of marketing was C. Schwarzler who, as head of the new division, will be responsible for planning and directing the development of new market areas and disseminating Foxboro instrument engineering information throughout the world. He will also direct the company's sales promotion and publication activities.

Charles Schwarzler, The Foxboro Co.

Sales growth in the domestic market has been reflected by the appointment of H. O. Ehrisman as vice-president and U. S. general sales manager. His primary responsibility will be the company's 61 branch offices in major industrial cities of the United States and related home office sales operations.

V. V. Tivy in his new position of director of engineering will be responsible for the interpretation of market trends in instrumentation and for encouraging the development and initial sale of new products to meet these trends. He will also continue as head of the company's systems engineering division.

Henry O. Ehrisman, The Foxboro Co.



Vincent V. Tivy, The Foxboro Co.

General Electric Co.

Liquid Silicone Rubber in Aerosol Cans

A liquid RTV (room temperature vulcanizing) silicone rubber in aerosol spray form has been put on the market by the Silicone Products Dept. of the General Electric Co., Waterford, N. Y.

The new aerosol form shows promise for applying a thin, uniform encapsulating coating on electronic assemblies and parts as well as a spray coating for easy release for molded plastic parts. Other uses are devloping in maintenance and other applications where thin, thermal, protective, shock absorbant, or nonconductive coatings are desired. Liquid silicone rubber in aerosol spray form possesses all of the desirable properties of conventional liquid silicone rubber. It has good physical and electrical properties and is resistant to temperatures from −65°F. to 600°F. It is resistant to many solvents and is unaffected by ozone, has its own "built in" release agent, and exhibits good bonding ability. Cure time varies from 15 min. to several hours depending on amount and type catalyst used.

Hubinger Co.

Thomas J. Neel is a recent addition to the sales-service staff of The Hubinger Co., Keokuk, Iowa. He is well known in the paper industry is a technical expert, and he is credited with important research and development on special uses of starch in papermaking. Neel will concentrate his activities as a Hubinger representative in the Middle West.

Hurletron, Inc.

Hurletron, Inc., a Delaware Corp., recently formed through the merger of two leading Illinois manufacturers of electronic and mechanical controls and components, has announced it newly elected officers.

Thomas N. McGowen, former chairman of the board of Electric Eye Equipment Co., assumes chairmanship of the new corporation. Mr. McCowen is also a director of Sundstrand Corp., Pabst, and other companies.

Elected president of Hurletron is Carl M. Noble, formerly president of Electric Eye Equipment Co. of Danville, Ill., one of the two merging companies and now a division of Hurletron, Inc. Mr. Noble became president of Electric Eye in 1948 upon the death of Sanuel C. Hurley, Jr., who founded the company in 1938. In the past 12 years this company has grown from a business occupying 8000 sq. ft. to a modern plant of 25,000 sq. ft. Only recently 12,000 sq. ft. were added to provide additional plant facilities for production of Hurletron Drives and new offices for the engineering staff.

As a manufacturer of precision automatic controls for application in graphic arts, papermaking, professional motion pictures and other industries, Electric Eye has increased its volume sevenfold since 1948.

Carl M. Noble, Hurletron, Inc.

Huyck Corp.

Formex Co.

Burgess de Heus, Formex Co.

Formex Co., Division of Huyck Corp., Knoxville announces the appointment of Burgess de Heus as Controller.

Formerly Huyck corporate manager of budgets at Rensselaer, N. Y., Mr. de Heus will be responsible for this new divisions' fiscal matters.

Formex is one of Huyck's newest divisions serving the paper industry, manufacturing synthetic fourdrinier wires at its production facility in Greeneville, Tenn. Construction has begun on its second plant at Kentville, N. S.

I-T-E Circuit Breaker Co.

Advanced design features of new K-Don current-limiting circuit breakers are detailed in a bulletin just published by the I-T-E- Circuit Breaker Co. The two-color, ten-page bulletin illustrates and describes the complete K-Don line which was introduced in October. The line combines 200,000 amp. interrupting capacity with complete range of operation of K-Line low voltage circuit breakers.

Copies of the new bulletin, No. 4300-1A, may be obtained by request to I-T-E Circuit Breaker Co., 1900 Hamilton St., Philadelphia, Pa.

Milton Roy Co.

A revised 32-page bulletin on controlled volume pumps has been released by Milton Roy Co., 1300 E. Mermaid Lane, Philadelphia 18, Pa. This Bulletin, No. 553-2, "Motor-Driven Controlled Volume Pumps," features a selection data guide, materials selection charts, and capacity-pressure selection tables.

Morningstar-Paisley, Inc.

Fast-Setting Folding Box Adhesive

A fast-setting polyvinyl acetate resin adhesive for modern folding box manufacturing operations has recently been developed by Morningstar-Paisley, Inc. The adhesive, called Solu-Rez 54-10301, is recommended for straight-line folding box work where deep bite and high speed are required. It can be easily cleaned from machine parts and reservoirs with water, without the need for solvents.

Further information about Solu-Rez 54-10301 can be obtained by writing Morningstar-Paisley, Inc., 630 West 51st St., New York 19, N. Y.

Seam Adhesive for Poly-Coated Bags

A unique modified latex adhesive developed especially for pasting side seams or bottoms and cross-seaming of multiwall polyethylene-coated kraft bags is now available from Morningstar-Paisley, Inc. The product, called M-P Bag Adhesive 1380, features strong bonds and unusually high mechanical stability, which allows it to perform without gumming up, coagulating, or building up along the sides of the glue pot. Through its consistently good machining properties, the adhesive helps keep bag quality high and reduces down time for glue pot clean-up operations.

Nalco Chemical Co.

Chemistry of Coagulation

The chemistry of coagulation applied to effective water treatment in municipal and industrial plants, practical approaches to problems, and solutions are discussed in an 8-page illustrated brochure, Bulletin A-1, offered by Nalco Chemical Co. Application of sodium aluminates; refined montmorillonites: cationic, anionic and nonionic polymers; and a new concept of "Inline Clarification," are among processes described. Nalco Chemical Co., 6216 W. 66th Place, Chicago 28, Ill.

Staff

David M. Jacks and Thomas G. Cocks have been named vice-presidents of Nalco Chemical Co. Both will serve as executive liaison officers, based in Chicago, and each will coordinate administration of several of the company's subsidiaries and divisions.

National Starch & Chemical Corp.

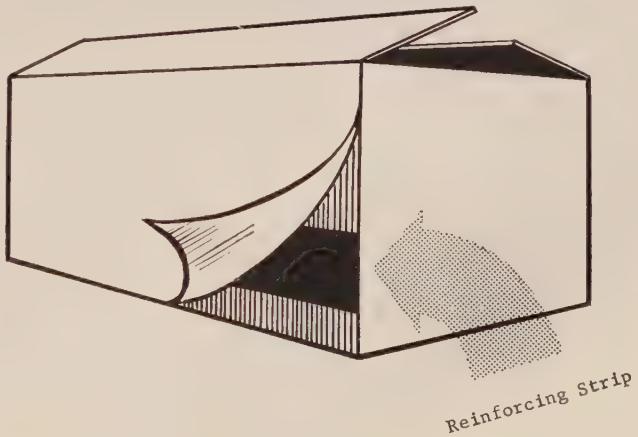
A completely new granular hot melt adhesive system, consisting of an Instant Lok hot melt applicator and the Instant Lok line of granular hot melt adhesives, has been perfected by the National Adhesives Div. of National Starch and Chemical Corp. and Potdevin Machine Co. of Teterboro, N. J. The complete system, the result of a joint development program by both companies, will be sold and serviced exclusively by National Adhesives. Potdevin Machine will manufacture the applicator units.

The Instant Lok system consists of a granular hot melt adhesive which is placed in a hopper and premelted by passage through a heated extrusion unit and then applied to the surface to be adhered through types of nozzles and applicators each designed for a particular use.

High among the many advantages offered by the Instant Lok system is the use of 100% solids material thus eliminating the cost of solvents and reducing container costs, transportation charges, and storage space. From a practical standpoint the Instant Lok system enables rapid startup time and eliminates the need for space consuming drying and compression units, as well as avoiding the need for daily machine cleanup time. There is no problem of adhesive feed as the application, in either continuous or intermittent form, is not subject to breaks or slow-downs. The system provides complete freedom from oxidation caused by exposed heating of the adhesive, and eliminates the need for premelt equipment. Instant Lok adhesives will not support mold and will not deteriorate during storage and thus present no shelf life problem.

Olin Mathieson Chemical Corp.

A new principle in corrugated container construction which provides extra strength where needed, yet eliminates costly



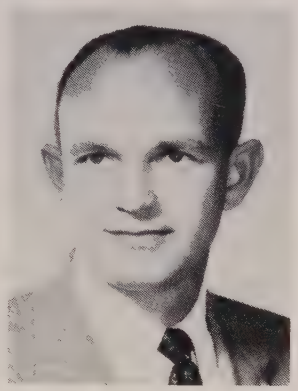
A strip of reinforcing material is laminated between the corrugating medium and the outer liner of a container to provide extra strength where needed, yet eliminate costly overpackaging. This technique, developed by the Packaging Div. of Olin Mathieson Chemical Corp., is described as a basic change in the method of increasing container strength

overpackaging, has been developed by the Packaging Div. of Olin Mathieson Chemical Corp.

The added strength results from laminating a strip of reinforcing material between the corrugating medium and the outer liner in certain areas of the container. M. H. Collet, vice-president and manager of the division's forest products operations, said this technique is a basic change in method for increasing container strength. Until now, container strength has been increased by increasing the weight of the entire package, even though some of the areas of the package do not need the extra strength. The technique, called "Armor-Gard," is the result of 5 years of research and testing, primarily with boxes used in the rubber and automotive industries. Tests on these containers showed that strip reinforcement increased bursting strength by 60% and puncture resistance by 48%.

Penick & Ford, Ltd.

Raymond I. Bashford, Jr., has been named to the position of manager, Technical Sales Service and Field Development, Paper Div., Penick & Ford, Ltd., Cedar Rapids, Iowa. Until recently, Mr. Bashford was located at Dayton, Ohio, as Penick & Ford's paper mill representative in the Central District.



Raymond S. Bashford Jr., Penich & Ford, Ltd.

Pfaudler Permutit, Inc.

Brazilian Co.

Formation of a new Brazilian company called Pfaudler Permutit Beneficiamento De Fluidas, LDTA, has been announced by Donald A. Gaudion, president of Pfaudler Permutit, Inc., Rochester, N. Y.

The new firm, which is located in Sao Paulo, becomes a part of the parent company's International Division. It will be under the direction of Dr. Ernesto E. E. Geiger and will be primarily occupied with engineering, subcontracting, and importing Permutit water conditioning equipment for the Brazilian market. In additon, the company will investigate the desirability of establishing facilities for manufacturing plastic and/or glass-lined vessels in Brazil.

Sale of both Pfaudler and Permutit company products in Brazil will continue to be the responsibility of Parson, Crosland and Cia LTDA which has handled sales for both divisions for many years.

Literature on Lab Size Drier

Data Sheet 51, describing a new 1-cu. ft. capacity Glasteel conical drier-blender, is available from The Pfaudler Co., a division of Pfaudler Permutit, Inc., Rochester, N. Y.

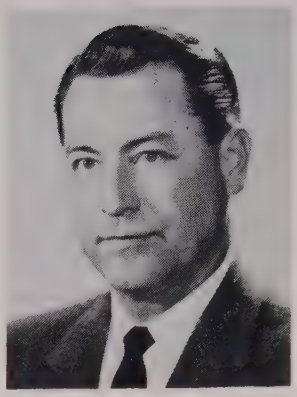
The unit is intended specifically for use in research laboratories, pilot plants, education institutions where small batch drying and blending are required plus subsequent scale-up to production size equipment. The data sheet gives complete specifications for the drier-blender, and includes a synopsis of operating data.

Among the advantages of the Glasteel construction detailed in the pamphlet are corrosion resistance, elimination of possible product contamination, easy cleaning, and less drying time.

For further information, write for Data Sheet 51 to The Pfaudler Co., 1122 West Ave., Rochester 3, N. Y.

Philadelphia Quartz Co.

One hundred years ago, the 21st of January, Philadelphia Quartz Co. made its first commercial sale of sodium silicate. The producer this year celebrates its 130th Anniversary. The founders of the company for the preceding 30 years were in the soap and candle business. Since 1904 Philadelphia Quartz Co. has specialized in the manufacture, development, and application of the sodium and potassium soluble silicates.



R. B. Park, Raybestos-Manhattan, Inc.

Frederick Coker, Jr., Rice Barton Corp.

Raybestos-Manhattan, Inc.

V-Belts

Design features and performance advantages of all R/M V-belts are detailed in a new 8-page bulletin issued by Manhattan Rubber Div. of Raybestos-Manhattan, Inc. Included are R/M Condor V-belts and patented R/M FHP V-belts, both offering special designs for heavy and light duty, short and long center applications. For copies of R/M V-Belt Bulletin M-201, write: Manhattan Rubber Div., Raybestos-Manhattan, Inc., Passaic, N. J.

Staff

R. B. Park is sales manager-Industrial Rubber and Mechanical Packings of Raybestos-Manhattan, Inc., Passaic, N. J., Mr. Park has been assistant sales manager of these sales activities since July, 1959. He was formerly district manager in San Francisco, having joined Raybestos-Manhattan in that city in 1954 after an extensive background in the distribution of industrial supplies.

R. B. Hazard, previously vice-president and sales manager-Industrial Rubber and Mechanical Packings, has now been appointed vice-president-sales for these sales divisions of Raybestos-Manhattan.

Rice Barton Corp.

Frederick T. Coker, Jr., Stamford, Conn., has been elected to the newly created position of executive vice-president of Rice Barton Corp., Worcester, Mass., it was announced by Charles S. Barton, president.

Mr. Coker, 37, has extensive experience in paper machinery and other manufacturing industries. Prior to joining Rice Barton, he was an associate partner with Booz, Allen & Hamilton, New York. Previously Mr. Coker has been coordinator of manufacturing and industrial engineering for the Lock and Hardware Div. of the Yale and Towne Manufacturing Co., and supervisor of standards and controls for M. L. Lowenstein & Sons.

S & S Corrugated Paper Machinery Co.

A 16-page brochure that describes and illustrates the new Model ZLM folder-gluer has been issued by S & S Corrugated Paper Machinery Co., Inc. The brochure describes the multiple-function versatility and flexibility of this new machine that was engineered for the utmost profitability by assuring uninterrupted, high-speed, low-manpower production of corrugated boxes.

The Model ZLM creases, slots, and rotary die cuts (or prints in one or two colors, with additional capacity for certificate printing), then folds, stacks, precision counts, and delivers squared piles of glued or taped boxes—all in one pass. Individual components and features of the machine are described and their functions explained. Generous illustrations show the principal details. Complete specifications of the ZLM are included, together with a functional diagram of operations showing the modular building block concept of combining units in any manner and number desired.

Copies of the new Model ZLM Folder-Gluer brochure may be obtained from S & S Corrugated Paper Machinery Co., Inc., 160 North Fourth St., Brooklyn 11, N. Y., or S & S International, Haarlem, Holland.

Stauffer Chemical Co.

West End Chemical Co.

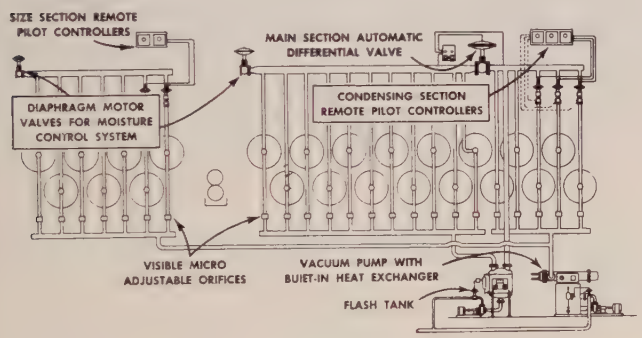
West End Chemical Co., Div. of Stauffer Chemical Co., has begun construction of an additional sodium sulfate production unit at Westend, Calif. Scheduled to be on stream by early summer of 1961, the expansion will raise West End's sodium sulfate output to 200,000 tons per year.

Stickle Steam Specialties Co.

Drier Drainage System

A new drier drainage system, that requires less major equipment, controls and accessories than other systems, is offered by Stickel Steam Specialties Co., 2215 Valley Ave., Indianapolis 18, Ind.

Designated as Type 3, the three-section system is said to cost less than any other comparable equipment to buy, install, operate and maintain because it uses fewer flash tanks,


SIZE SECTION REMOTE PILOT CONTROLLERS
MAIN SECTION AUTOMATIC DIFFERENTIAL VALVE
DIAPHRAGM MOTOR VALVES FOR MOISTURE CONTROL SYSTEM
CONDENSING SECTION REMOTE PILOT CONTROLLERS
VISIBLE MICRO ADJUSTABLE ORIFICES
VACUUM PUMP WITH BUIET-IN HEAT EXCHANGER
FLASH TANK

Stickle drier drainage system

pumps, motors, controls, control valves, and accessories. According to Stickel, savings on equipment and engineering costs alone usually run between 10 and 70%. The system is designed for paper machines operating on medium and low pressures, and on vacuum.

Tepper Corp.

George R. Hoffman, former chairman of the board of the Biddle Purchasing Co., and more recently associated with the United States Plywood Corp., as a marketing consultant, on January 1 joined the J. J. Tepper Corp., R.C.A. Building, New York, N. Y.

Mr. Hoffman will establish and direct a department of market counselling for the Tepper organization who are specialists in business acquisitions, mergers, and special situations in diversified fields.

Prior to joining U. S. Plywood in 1957, Mr. Hoffman spent many years with Biddle Purchasing where, starting as mail boy, he ultimately became chairman of the Board. As a Colonel in the Army Transportation Corps during World War II, Mr. Hoffman had the assignment of Port Transportation Officer of the Port of New York.

Thwing-Albert Instrument Co.

Facts on Testing

Bulletin No. 5901 "Facts on Testing" is available. This bulletin tells about the combined tensile and tear tester sample cutter, air operated grips for tensile tester, capstan grips for textile tensile testing, the adhesives tester, the four square cutter, the spencer impact attachment for the Elmendorf tearing tester, toughness tester attachment for the Elmendorf tearing tester, and Elmendorf calibration check weights.

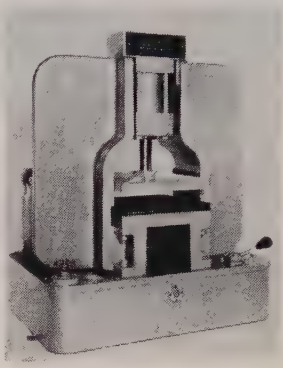
Alfa Laboratory Sample Cutter

Thwing-Albert Instrument Co. announces the development of a new electro-hydraulically operated laboratory sample cutter.

The Model No. 240-4 Alfa Laboratory Sample Cutter, more powerful than hand-operated models is adjustable to apply up to 8 tons of pressure at the cutting surface.

Effortless finger tip operation makes it possible to cut larger, thicker, and harder laboratory samples of tissue, paper, paperboard, textiles, plastic, rubber, carpeting, etc.

Inexpensive Alfa sample dies make it possible to change from one size sample to another in seconds.



Alfa laboratory sample cutter

U. S. Industrial Chemicals Co.

Caustic Soda Booklet

A new 40-page booklet giving complete chemical and physical properties on caustic soda is available from U. S. Industrial Chemicals Co., A division of National Distillers and Chemical Corp. Copies may be obtained from the Technical Literature Dept., U. S. Industrial Chemicals Co., 99 Park Ave., New York 16, N. Y.

Petrothene Resin Uses

A four-page data sheet listing the most commonly used "Petrothene" polyethylene resins, their main characteristics, and their predominant applications, is available from U. S. Industrial Chemicals Co. Several of the many available compounded resins are listed also.

Designated PRTD-1, this data sheet is meant to serve as a general guide. It is not a listing of all Petrothene polyethylene resins or all possible applications. Copies of this publication may be obtained by writing U. S. Industrial Chemicals Co., Div. of National Distillers and Chemical Corp., 99 Park Ave., New York 16, N. Y.

Valmet Oy

Between the Russian import organization Techmashimport and Valmet Oy, Finland, a contract has been signed according to which Valmet during 1962–63 will deliver to the Soviet Union a machine plant for the manufacture of high-yield sulfate pulp and kraft liner.

The annual production capacity of the mill will be 280,000 tons kraft liner board. Subdeliveries for this plant will be effected by several other outstanding Finnish contractors.

R. T. Vanderbilt Co.

Ray F. Harter becomes manager of the Paper Dept. of the R. T. Vanderbilt Co., Inc., 230 Park Ave., New York, N. Y. He has been with the company nearly 26 years and

the past 10 years as assistant manager. Prior to this he was employed by the A. E. Staley Co. and the old Kalbfleisch Corp. Ray is well known throughout the United States and Canada.

Richard M. Talbott, who has been for the past 6 years New England and Eastern New York sales representative, now becomes assistant manager of the Paper Dept. Prior to this he worked for 3 years in the company's Paper Laboratory at East Norwalk, Conn. and also during this period was very active in sales service work. Dick previously was employed by the Longview Fibre Co. for 2 years as a chemical engineer. He also was active in the Second World War and Korean War as a naval officer finally resigning as a Lieutenant.

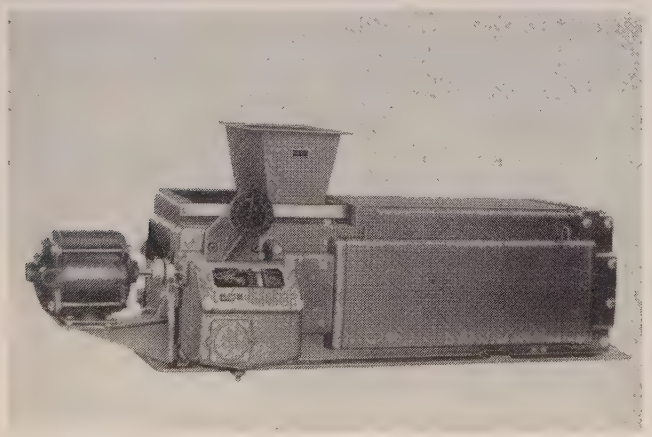
William L. Craig becomes coordinator for the Paper Dept. This is a new position created for closer work between the New York office and the Paper Laboratories located at 33 Winfield St., East Norwalk, Conn. Bill has been with the company 24 years. He will continue to make his headquarters at East Norwalk, Conn.

Wallace & Tiernan, Inc.

Volumetric Feeder

A new volumetric feeder, the Merchen volumetric, has recently been added to its extensive feeder line by Wallace & Tiernan, Inc., Belleville, N. J. The new feeder measures all free-flowing powdered, granular, or lumpy solids by volume, and has a maximum capacity of 3600 cu. ft. per hr.

The new Merchen is the only volumetric feeder with belt-and-feed-gate design. Models are available with 9 or 18 in.



W & T Merchen volumetric feeder

Buna-N feed belts. The smaller model feeds from 0.1 to 600 cu. ft. per hr.; the 18-in. model, from 0.6 to 3600 cu. ft. per hr. Depending on the density of the material fed, this is the equivalent of 3 to 3000 lb. Feed rate is adjustable by a simple dial setting over a 10:1 range. Accuracy is maintained within±3% over any 1-min. period.

An illustrated 4-page catalog and further information on the Merchen volumetric feeder is available from Wallace & Tiernan, Inc., 25 Main St., Belleville, N. J.

General

Abstracts of Selected Articles from Communist Technical Journals

Abstracts of selected articles from Soviet Bloc and Communist China technical journals in six general subject areas will be published monthly and sold on subscription by the Office of Technical Services, Business and Defense Services Administration, U. S. Department of Commerce, according to John C. Green, OTS director.

OTS, which is the Federal Government's "clearinghouse" for translations and reports of Government-sponsored research, will offer this program beginning in late January, in place of one discontinued last June under which cover-to-cover abstracts of some 100 Russian technical journals were published, Mr. Green said. The old program was discontinued because of the small number of subscribers to the journals abstracted on the cover-to-cover basis.

The abstracts will be prepared by another agency, but copies will be furnished to OTS for publication and sale to the public. The time lag between publication of the original article in the Soviet bloc or Chinese press and publication of the abstracts by OTS is expected to approximate 70 to 120 days, Mr. Green said.

Subscriptions to the six new publications, or series will be accepted for a 6-months' period. The six series, or publications, are listed below, with the estimated number of abstracts per month and subscription prices.

		Estimated number of abstracts per month	*Subscription for 6 months*
I.	Physics, geophysics, astrophysics, astronomy, astronautics, and applied mathematics	225	$9.00
II.	Chemistry, chemicals, and chemical products	150	$6.00
III.	Metallurgy, metals, metal products, and nonmetallic minerals	450	$18.00
IV.	Engineering (mechanical, electrical, aeronautical, and nuclear, petroleum, structural, & civil) machinery and equipment (general and special purpose)	225	$9.00
V.	Communications, transportation, navigation, electrical and electronic equipment, systems and devices, including aircraft and missile equipment	225	$9.00
VI.	General science and miscellaneous including meteorology, oceanography, biology, astrobiology, botany, zoology, medical science, aeromedicine, education, fuels, fuel products, power, etc.	225	$9.00

For further information on these abstracts, write to Publications & Public Information Division, OTS.

Packaging Booklet

A new edition of "The Folding Carton," an illustrated booklet widely used in packaging, will be distributed in January by the Folding Paper Box Association of America.

A new feature of the publication will be an extensive glossary of terms used in the manufacture of folding cartons. Also included are diagrams of the most popular carton styles, complete descriptions of the manufacture and use of cartons, and instructions for ordering.

This is the second revision of the booklet which was originally published in 1950. Back orders for the publication, which has been out of print for several months, will be filled by the FPBAA rapidly as possible.

Corrugated Expendable Pallet

A bantam-weight corrugated pallet, providing industrial shippers with a low-cost and easily transportable base capable of carrying strapped loads as heavy as 10,000 lb., has been introduced by Packaging Corp. of America.

Called Econo-Pal, it weighs only 3 to 4 lb., depending upon the size selected. Cost is far below that of conventional wooden type pallets in use today. When unitized to a load, it can be shipped by any method of transportation.

One man using a staple gun can assemble the Econo-Pal in a few minutes by simply folding and stapling the single

(Left) Corrugated expendable pallet, designed by Packaging Corp. of America, can be assembled from one-piece of corrugated board within a few minutes by a single worker with a staple gun. A variety of specially designed corrugated support fillers provide increased strength when needed. Compression strengths have reached 51,000 lb. in testing by the company. (Right) The pallet is strapped to loads for maximum strength. Weighing only 3 to 4 lb., the new pallets save both shipping and storage costs. Shipped flat to users, they take only one tenth the space of conventional wooden pallets

die-cut and scored sheet as directed. To speed up the assembly, the company has designed as optional custom assembly jig which enables two workers to put a pallet together in about four minutes with the aid of a staple gun.

Leg design of the pallet permits easy four-way entry by fork lift trucks. The pallet legs are double- and triple-ply corrugation to insure maximum strength. Extensive testing in Packaging Corp.'s Grand Rapids, Mich., packaging design laboratory have proved that compression strength as high as 51,000 lb. can be attained through the use of the special inserts.

For more technical details, contact "Pallet," Packaging Corp. of America, 1632 Chicago Ave., Evanston, Ill.

Sulfur

Sulfur experienced a good year in 1960. Domestic consumption and exports were at record levels, and important additions to productive capacity were made. This summation was provided by Charles A. Wight, president of Freeport Sulphur Co., in an annual review of the United States sulfur industry.

Demand for sulfur increased for the second consecutive year as a result of the high rate of industrial production at home and abroad. Sulfur, long regarded as a barometer of business activity, is used in making fertilizers, chemicals, paper, steel, rubber, textiles, and innumerable other products.

Preliminary data indicate that total domestic consumption of sulfur in all forms was in excess of the previous high of 5,950,000 long tons used in 1959. Consumption in 1959 was 11% over 1958. The phosphate fertilizer industry, which had a record year, was a particularly strong factor in the sulfur market.

The high level of business activity elsewhere in the Free World led to greater than ever exports of sulfur from the United States. Such shipments were estimated to total 1,700,000 tons, up 100,000 tons over 1959. The new high was achieved despite an increase of 600,000 tons in the shipments of other producers supplying the overseas markets.

Domestic sulfur production was up about 7%. Output from all sources amounted to an estimated 6,600,000 tons, compared with 6,165,000 tons in 1959. Of the total, an estimated 4,950,000 tons was elemental sulfur mined by the Frasch hot-water process from salt dome deposits along the coast of Louisiana and Texas. Of the balance, 725,000 tons represented elemental sulfur recovered from sour natural gas and refinery gases; 425,000 tons sulfur contained in pyrites; and 500,000 tons sulfur in various forms from other sources.

During the year, three new Frasch mines were placed in operation on the U. S. Gulf Coast. The largest new mine was Freeport's Grand Isle project, located 7 miles off the shore of Louisiana in 50 ft. of water. This gain in productive capacity was partially offset by the announced closing of two other mines, one in Louisiana and one in Texas.

OBITUARY

Marcy B. Newell

Marcy B. Newell, 54, mill process engineer, Ecusta Paper operations of the Packaging Div. of Olin Mathieson Chemical Corp. at Pisgah Forest, N. C., died in a Durham, N. C., hospital on Monday, Jan. 2, 1961.

A native of Boulder, Colo., he graduated magna cum laude from the University of Colorado in 1928 with a B.S. degree in chemical engineering. After graduation he was employed in the mining business with his father for one year.

From 1929 to 1932 Mr. Newell was a paper technologist with the General Electric Co. at Pittsfield, Mass. For the following four years he was employed by Bird & Son at Walpole, Mass., as a research engineer, and in 1936 he joined Steven Paper Mill as superintendent of the Taylor-Atkins Division. Employed by Peter J. Schweitzer Paper Co. in 1939 as mill manager, Mr. Newell left in 1948 to form his own mining company in Montezuma, Colo. He joined Ecusta in 1949.

Survivors are his wife, Stephanie, of Brevard, N. C.; a son, M. L., of San Francisco, Calif.; a daughter, Mrs. Robert Sheppard, of San Jose, Calif., and two grandchildren.

Mr. Newell was a member of the Technical Association of the Pulp and Paper Industry, American Society of Chemical Engineers, and Alpha Chi Sigma, honorary professional chemical fraternity.

Burial was in Boulder, Colo.

TAPPI DIVISIONS AND COMMITTEES

Reports of Activities

Corrugated Containers Division

Raw Materials Committee (Medium and Liner Subcommittee)

The meeting began with the suggestion that the Raw Materials Committee discontinue having subcommittees, and, in place of these subcommittees, hold a general meeting and distribute projects among the entire raw materials group.

The letter from John Hart to Bert Jones, giving the results of a preliminary study of wet streaks and the operational difficulties caused by them, was passed around. It was decided that a copy of this letter would be distributed with the minutes of the meeting.

The pin-pull and water absorbency project which was made by Lanzit and Menasha Wooden Ware was reviewed, and all agreed that there was no correlation between pin-pull and water absorbency of medium and liner. Mr. Magnuson stated that the moisture in liners causes many variations in the butyl-carbitol test and that this could be the reason for the wide variations in the B. C. results. Mr. Morris suggested that high sized medium will not absorb moisture, but might have a good moisture vapor transmission rate, and, therefore, a water vapor transmission test could be of some value.

Mr. Robson asked for suggestions of new projects and obtained the following:

1. Wet streaks versus runnability.
2. Mr. Adickes suggested that each member write a list of variables that may occur in a liner and medium and have this list for presentation at the February meeting. He suggested that one method of obtaining this list would be to keep a pad on the desk and, as the various variables occur, jot them down.
3. It was suggested that we get representation from the Testing Committee at our February meeting so as to conduct a brainstorming session for new projects.
4. A request was made that all members compile records of wet rolls and problems that were encountered with these rolls for presentation at the February meeting.

FRANK ALBERT

Raw Materials Committee: G. R. Wilmer, chairman, Packaging Corp. of America, Grand Rapids, Mich.; A. L. Magnuson, vice-chairman, Potlatch Forests, Inc.; Lewiston, Idaho; R. Gibson, Secretary, St. Joe Paper Co., Port St. Joe, Fla.

Engineering Division

Chemical Engineering Committee

Minutes of the previous luncheon meeting at the 45th Annual TAPPI Meeting in New York were read and accepted with a minor correction. John Lewis was erroneously mentioned as vice-president instead of vice-chairman.

E. F. Thode reported on the Operations Research Subcommittee. He explained that this subcommittee is now in an interim period prior to the establishment of a new full committee. E. H. Olmstead is acting as advisor. A subcommittee meeting to be held after this meeting to discuss new committee charter. Four areas of service for new committee include: Helping other committees on applied mathematics, cooperation on research projects, educational function on applied mathematics and the demonstration of automation in the industry.

S. W. McKibbins reported on the Chemical Engineering Subcommittee. Thirty-eight problems have been presented and will be submitted for editing which should be completed in December. They should be presented at the February meeting and then published in loose leaf folder. There are ten major areas of Chemical Engineering Problems. Problems will be added as time goes on. The Chemical Education Program for colleges is being withheld for completion of problems.

L. W. Zabel, chairman of the Subcommittee on Process Dynamics reported that he is soliciting members. Mr. Zabel made a motion that a project on the mixing and blending of pulp be submitted for TAPPI approval. This motion was seconded.

Project No. 817 on gas absorption has been submitted for approval. If approved, work will be done by Dr. G. Moon at the University of Cincinnati. This will cover the absorption of sulfur dioxide in a variety of alkaline media.

R. F. Clemens reported that a committee newsletter had been submitted to *Tappi* covering chiefly the activities of our subcommittees and had been well received. A. J. Winchester mentioned that newsletters should not cover minutes of committee meetings since they are not of interest outside of the committee.

John Lewis reported for A. J. Chase, chairman of the Data Sheet Committee. No new data sheets have been processed but it is expected that some sheets will be prepared for the February meeting. Mr. Chase submitted a letter listing some of the material on hand for processing.

A. W. Plummer announced that TAPPI Headquarters is now recruiting for a full time man to dissimilate technical information. He also mentioned urgency of submitting Data Sheets to Mr. Chase in usable form.

A W. Plummer mentioned the Question & Answer column in *Tappi*, and that H. L. Warner had been assigned the review thereof for project sources ideas. Mr. Warner plans to submit a report on this. E. H. Olmstead commented that committees are being requested to stimulate this column.

A. W. Plummer requested technical papers from members. The response so far has been very poor. A plan to hold each member responsible for obtaining one paper might be considered. S. W. McKibbins expressed some thoughts on

chemical engineering papers and was requested to present these thoughts in a letter to the committee.

Nonmembers present were requested to take pledge forms for membership, if interested

H. W. Hemphill of Singmaster & Breyer, Inc., commented on Singmaster & Breyer's program on nitric acid pulping. Feelings were expressed that pulp and paper might not be up-to-date on chemical engineering in other industries. Young, inquisitive chemical engineers might well advance revolutionary processing changes in the industry.

Many of those present had to leave at this point (about 1:45 p.m.) due to technical sessions following.

Mr. Plummer announced that Mr. Clemens, the secretary, had found it necessary to resign from the committee since his position with Dorr-Oliver now occupied him almost entirely outside of the pulp and paper industry. Mr. Clemens expressed his regrets at having to take this step and extended his best wishes for the committee's future.

An informal discussion on our problems followed until about 2:00 p.m. when the meeting was adjourned.

R. F. Clemens, *Secretary*

Preparation of Chemical Engineering Problems Subcommittee

On October 25, 1960, a meeting of the subcommittee on Project No. 780 was called at the Robert Meyer Hotel in Jacksonville, Fla., during the 15th TAPPI Engineering Conference.

It was felt that several problems aimed at the graduate level should also be included in the problem book. Bill Ingmanson agreed to supply several such problems. The importance of removing "jargon" peculiar to the industry in all the problems was emphasized. To aid in this and in the checking of solutions, it was suggested that several graduate students be hired to read and evaluate the problems. There are presently 38 problems available.

It was agreed that the book follow this format:

Loose-leaf binder of high quality.
Problems to be printed—not mimeographed, etc.
Separators used to divide the problems into the ten areas previously agreed on.
Include an introduction, several flow diagrams, and index. TAPPI and the Chemical Engineering Committee should receive acknowledgment. Questions, comments and additional problems will be solicited and should be sent to TAPPI, New York, N. Y.
Include all necessary data in problems but, where applicable, note which comes from standard references and might be deleted.
All problems should be numbered according to group (Stoichiometry, Kinetics, etc.) and problems (e.g., 1-1; 1-2; etc., where 1 might refer to Stoichiometry).
Liberal use of photographs of equipment.

It was decided that the problem should be readied for publication as soon as possible. The following time-table was agreed on:

November 1–December 31:
Submit problems to graduate students (probably at University of Wisconsin) for checking of solutions and presentation.
Have necessary diagrams, graphs, and photographs prepared.
Introduction, table of contents, etc., be prepared.
Herb Teeple will collect and submit for approval various binders for containing the problems.

January 1–January 15:
Ingmanson, McKibbins (and any other interested subcommittee members in the Wisconsin area) will take a final, definitive look at the problems and forward them to the other committee members and to Herb Teeple in New York.

January 16–January 31:
The committee members will have then two weeks to contact Herb Teeple about any final revisions in the problem. At the end of this period he will submit them to the printer.

February 1–February 19:
The first galley proofs should be available for inspection at the TAPPI Annual Meeting in New York. Publication of the problem book should then follow in a few weeks.

Samuel W. McKibbins

Drying Committee

The luncheon was called to order at 12:30 p.m., Oct. 24, 1960, at the Robert Meyer in Jacksonville, Fla. by the chairman. The minutes of the previous meeting were approved.

New members and guests were introduced.

A new slate of Drying Committee candidates have been nominated. S. G. Holt and K. K. Khandelwal have served 3-year terms and Vice-Chairman G. E. Jackson desired to vacate his office due to excess pressure of work at his mil . The following are the new candidates of the Drying Committee who will take over following appropriate approvals.

John Verwayan, chairman
Fred G. Perry, vice-chairman
J. A. Villolobos, secretary

Review of program and arrangements for the Drying Committee Session at the TAPPI Engineering Division Conference at Jacksonville, Fla.

S. G. Holt, for the benefit of new members, stated that the subcommittee basis of organization for the Drying Committee was discarded a year ago. Now the groups within the Drying Committee are organized as task forces to work on specific projects.

S. G. Holt had mailed to all committee members a list of 15 proposed projects for the Drying Committee. These projects had been developed with the cooperation of the Engineering Division staff. Mr. Olmstead pointed out that many of these projects fit into the area of technical work suggested Paul Baldwin, executive vice-president of Scott Paper Co.

There was some discussion followed by a decision that the committee members will be polled by mail to indicate their area of interest for project tasks.

Following is the list of 15 projects proposed.

1. Development of a standard TAPPI method for obtaining the performance characteristics of high velocity air hoods and drying systems.

2. A method for measuring the surface temperature of driers and drying webs.

3. Methods for measuring the moisture content (specific moisture relative humidity) of drying system air (supply and exhaust).

4. Development of standard nomenclature for expressing moisture content or dryness, with some means of conversion for current terms. (data sheet?)

5. Information on thermal energy cost per pound of water removed at different moisture contents.

6. Extend "Methods for Moisture Sampling of Paper" to include press section sampling.

7. Survey of high performance hood on paper machines and coaters. Suggest that data be presented as a curve of drying rate with high performance hood in terms of equivalent cylindrical driers versus moisture content, for a certain furnish of coating.

8. Survey of drying rates with low pressure driers to supplement project 505 (Drying Rates with High Pressure Steam in Paper Machine Driers). A new method of presentation is suggested if possible to avoid the wide spread in data.

9. Effect of drier felt variables on drying rates. Quantities such as felt tension, moisture content, constructions, etc. to be investigated.

10. General bibliography of drying.

11. Yearly review of significant articles and significant developments in drying.

12. Survey of exotic heating methods for drying purposes (high pressure water, hot oil, Dow therm, etc.).

13. A research program, perhaps under TAPPI sponsorship to cover:

A. The aerodynamic characteristics of high velocity types of drying systems.
B. Heat transfer characteristics of high velocity types of drying systems.
C. Mass transfer and diffusion in high performance drying systems.

14. Comparison of coating drying and paper drying performance of various types of commercial drying equipment.

15. Paper defects due to drying (printing grades in particular).

Review of Current Projects

Project No. 505. Drying Rates with High Pressure Steam in Paper Machine Driers. W. K. Metcalfe reported for L. G. Janett, stated that the preliminary report was in the hands of H. O. Teeple (TAPPI Headquarters) who is having it printed. Data on high pressure driers was reported at the Pittsburgh conference in October, 1959, and L. G. Janett was working on tabulating the information and completing the report.

Project No. 756. High Frequency Drying (electrical). L. R. Vianey reported that he had communicated with three or four companies manufacturing high frequency current generators and found out that only the wood industry was using high frequency drying.

Project No. 757. Radiant Heat Drying. (R. C. Swaney, J. J. Killian). In the absence of R. C. Swaney, S. G. Holt stated that the Radiant Heat Drying Session on October 26, 1960, completes the project on radiant heat from gas sources and the project's aim should be to pursue for information on radiant heat from electrical source.

Project No. 759. Gas Turbines in Pulp & Paper Mills (R. C. Swaney, J. J. Killian). This project will be kept on active list as there is continuing interest in this field.

Project No. 760. High Velocity Air Jet Driers (L. Blomgren, W. K. Metcalfe, W. Overly). The session on Oct. 25, 1960, at the Engineering Division Conference will complete the immediate target of this project but in the long range this project will continue to bring forth technical information in the form of papers for the future conferences.

Project No. 890. Methods of Moisture Sampling of Papre (J. J. Killian, D. Pohlman, N. M. Reitzel, G. Krikorian). The task force for this project will hold a meeting this week and make arrangements for sending out a questionnaire to the mills requesting information on their methods of sampling and testing for paper moisture.

Chairman-elect John Verwayan stated that as of this moment there were no papers available for scheduling for the 1961 Engineering Division Conference and consequently all committee members make earnest effort to arrange for new technical papers. He suggested possibilities of locating further papers on high velocity air driers because of the continuing interest for this in ndustry. J. A. Villalobos said that the committee should keep in mind possibilities of establishing performance of h gh velocity air driers as a potential paper.

General Business

1. D. Pohlman inquired with regard to his communication to the committee on the error in the TAPPI'S Drying Rates Data Sheet.

2. It was stated that when task forces are established for the new proposed projects the groups should be formed by taking into account the geographical location of the subcommittee members so that they could conveniently hold meetings as needed.

3. Engineering Division Staff representatives E. H. Olmstead pointed out that the TAPPI magazine's section on questions and answers was a new service to the pulp and paper industry and any questions and answers generated in the Drying Committee should be transmitted to N. Shonmatoff for publication.

The meeting was adjourned at 2:30 p.m.

Krishna K. Khandelwal, *Secretary*

Fluid Mechanics Committee

The Fluid Mechanics Committee, Engineering Division, met in Room E of the Commodore Hotel, New York on Feb. 24, 1960, at 12:15 p.m. for a luncheon meeting with C. A. Lee, chairman, presiding.

The chairman opened the meeting by introducing the various guests to the members present.

Mr. Smith read the minutes of the last meeting of the Fluid Mechanics Committee at Pittsburgh, Pa. on Oct. 13, 1959, which minutes were approved unanimously without changes.

There then followed reports by the subcommittee chairmen on the activities of the various subcommittees.

Dr. Mason, as chairman of the Subcommittee on Dilute Fiber Suspensions, reported that the proposal for continuation of Research Project No. 172 at Massachusetts Institute of Technology on "Turbulent Transfer Mechanics With Neutrally Buoyant Suspensions" had been approved in the amount of $17,750.00. This work will continue under the supervision of Professors Ippen and Daily with the study being conducted by a new candidate for a doctoral degree inasmuch as Dr. Bugliarello has received his degree and is now teaching at the Carnegie Institute of Technology. Dr. Mason proposed a meeting at M.I.T. in the fall of 1960 after the new investigators have had an opportunity to become oriented in the problem.

Dr. Mason indicated that it might be inadvisable to publish at present a monograph on the work conducted to date at M.I.T. and suggested that this might be subsequently developed by members of the committee rather than by personnel at M.I.T.

With respect to reports covering the results obtained thus far under prior grants under the auspices of the Subcommittee on Dilute Fiber Suspensions, Mr. Lee pointed out that such reports will be available after publication in *Tappi*. Dr. Mason has suggested to Professor Daily that these reports be published as a series of papers in *Tappi* and also recommends they be published simultaneously in professional journals so as to reach individuals on a scientific level inside and outside of the pulp and paper industry. By this means the interest of professional people in the fluid mechanics field would be further focused on the work conducted under TAPPI auspices.

In response to a question by Dr. Ingmanson as to whether the idea of a monograph had been completely abandoned, Mr. Lee stated that it had not, but that it was perhaps best to allow investigators at M.I.T. to focus on research with work of editorial compilation and writing of reports by others. The subject of how such a monograph might best be compiled is of interest to all committee members and could be the subject of intensive study.

Mr. Lyall suggested the possibility of publishing these reports in a series of papers in *Tappi* be discussed with the TAPPI Editorial Board. The chairman agreed that this would be done.

To date, according to Dr. Bugliarello, two such papers have been published, one in *Tappi* and the second in the *Journal of Industrial Chemistry*. He also reported that Professor Daily has in mind three additional papers, one in the laminar field and two covering flows in the turbulent region. These would constitute the series of papers referred to by Dr. Mason.

Mr. Lyall moved that the recommendation of the Subcommittee on Dilute Fiber Suspensions with respect to the publication of the M.I.T. reports be approved. The motion was carried unanimously.

Further discussion of the subject ensued with Messrs. Mason, Mackenzie, and Mardon participating. The following points were evolved. Dr. Mason referred to the importance of allowing researchers to report in their own manner and in the professional journals in their fields. He said that papers published in *Tappi* do not necessarily become known to specialists in the field of fluid mechanics because in the usual

library indexing *Tappi* is classified under the field of "Pulp and Paper Technology" rather than "Fluid Mechanics." Mr. Mardon suggested that simplification of the overall scope and results of research projects was sometimes necessary and that this could best be accomplished by others than the original investigators. It was Mr. Mackenzie's opinion that most paper companies today have a sufficient number of scientific level personnel to understand both the basic fundamental reporting on a professional level as well as a more popularized version. It was concluded reports might be published in both mediums, with *Tappi* having priority with respect to time, as this is the established policy of TAPPI Engineering Division. Dr. Nissan mentioned that he was especially interested in the subject as he was to present a prepared talk on it the next evening.

Mr. Mackenzie, as chairman of the Subcommittee on Pipe Friction, then reported the recent activities of his group. There has been a widespread endeavor to increase the use of the shear tester among paper companies as a result of a subcommittee meeting at Pittsburgh following the Engineering Division meeting in October. His subcommittee proposes that a young engineer be hired who, after preliminary training, would visit the various paper mills to acquaint them with the use of the shear tester on pulp slurries. The expense of such a program would be shared by the centrifugal pump manufacturers whose representatives on the committee had indicated their support. This support was estimated to be 50% of the total cost. The latter was estimated at $10,000 of which TAPPI grant would be required in the sum of half this amount. Mr. Lee pointed out that request for such a grant to be effective this year must be submitted to the Research Appropriations Group by April 1. Mr. Lyall pointed out that the program seemed to fit in with the TAPPI Executive Committee recommendations regarding the support of research programs by TAPPI corporate members.

On a motion by Mr. Mardon a vote of confidence in this program by the Subcommittee on Pipe Friction was made and approved unanimously.

Dr. Nissan discussed the relative historical positions of fluid mechanics and hydraulics from the standpoint of courses as they are defined and taught in our universities and pointed out the desirability of a marriage of these subjects in considering any program of research in either field.

In the absence of Mr. Wrist, chairman of the Subcommittee on High Speed Free Surface Flows, Mr. Spengos reviewed this program at the request of the chairman. Mr. Spengos read the minutes of the meeting of this subcommittee on Feb. 4, 1960, at the University of Michigan in Ann Arbor, Mich. At this meeting Mr. Spengos was appointed the vice-chairman and Mr. Lamb, secretary of the subcommittee. The subcommittee is requesting a TAPPI Research Appropriation Grant in the amount of $14,500 to continue the work under Project Grant No. 156 at the University of Michigan on the subject of free surface flows.

Mr. Shoumatoff mentioned that this report was quite encouraging and proposed a motion to approve this request which would involve the further participation of Dr. C. S. Yih who is now at Oxford University, England. Further benefits would be derived from Dr. Yih's current association with Professor Taylor in allied work in this field.

Mr. Lee then announced the formation recently of a new Subcommittee on Flow Through Porous Media with Dr. Ingmanson as chairman. Dr. Ingmanson reviewed the program which will be presented under the auspices of the Fluid Mechanics Committee at the forthcoming meeting of the Engineering Division in October, 1960, at Jacksonville, Fla. In addition to the formal papers which have already been submitted and approved, it was suggested that an outside speaker who is an authority in the field of fluid mechanics be engaged. In this connection Dr. Mason inquired concerning TAPPI policy with respect to having subcommittee members who are not members of the parent committee nor of TAPPI. Mr. Lee stated that it definitely was TAPPI policy to have such subcommittee members.

Mr. Calehuff, chairman of the Data Sheet Subcommittee, then submitted his report. First, he requested members to submit a list of reference books to which they refer frequently, occasionally, or as a last resort. This information will be compiled by his subcommittee and returned to the Engineering Division Data Sheet Committee. Mr. Calehuff reported that the Data Sheet Review Committee had returned Data Sheets on Stock Friction, No. 205, and Centrifugal Pumps, No. 4, which sheets with a few minor corrections were now satisfactory.

There then ensured a discussion of new committee projects. Mr. Lee mentioned that as the need arose new subcommittees would be instituted in the future to handle such new projects. He said that results of recent questionnaire requesting members to indicate their choice as to subcommittees will be forwarded to the respective committee chairmen so that the latter can then select their membership. Dr. Mason suggested that subcommittee membership be kept within the scope and convenient sized group for effective contribution.

Mr. Lee stated that the forthcoming technical sessions of the Fluid Mechanics Committee at the Jacksonville meeting in October, 1960, would be on Monday and Wednesday afternoons, October 24 and 26, with a luncheon meeting on October 25.

Mr. Mackenzie indicated that a paper covering data on "Friction Loss Through Pipe Fittings" might not be completed until July or August, but could constitute a short informal paper. Dr. Mason indicated that Professor Daily could give a final report, but would prefer not to request this as no meeting of his subcommittee is contamplated until the fall of 1960. The committee agreed with this suggestion.

Mr. Lee pointed out that the committee should be prepared at the fall meeting to define papers for presentation in 1961 to be in accord with Engineering Division policy requesting committees to have definite commitments on papers by that time

Under the subject of new business Dr. Mason referred to a forthcoming meeting at Oxford University on September 24 and 29, 1961, on the subject of "Effect of Papermaking Variables on Paper Properties." This meeting will focus on various aspects of fluid mechanics as applied to the papermaking process. Individuals interested in attending this conference may contact Hector Emerton or Albert E. Read at Oxford University.

Mr. Mardon then presented an excellent high speed moving picture of the flow of stock on the wire on newsprint machines which was of great interest. This was concerned primarily with spouting and ridge formation and their causes and corrective measures to reduce their detrimental effects in the finished sheet. These pictures had not previously been presented in the United States or Canada but had been presented by Mr. Mardon abroad during his recent visit to Finland.

J. A. Smith, *Secretary*

Fluid Mechanics Subcommittee on Free Surface Flows

The meeting which was held at the University of Michigan, Ann Arbor, on Feb. 4, 1960, opened with subcommittee appointments of A. C. Spengos to vice-chairman and C. A. Lamb to secretary.

P. E. Wrist presented the agenda for the day which was well followed throughout the meeting. The first part of the meeting was devoted to a review of the scope and intent of the work at Michigan. Dr. Debler then presented the results of the past year's work. This was followed by a summary of the benefits of the project and a discussion of future work which would be the basis for an application to the Research Appropriations Committee for a new TAPPI project grant.

Scope and Intent of Project

Wrist read the original project write-up and reviewed the reasons for some of the changes which were made at the subcommittee meeting in January, 1959, and subsequently reported in the minutes of that meeting published in *Tappi*. The primary deviation was to postpone indefinitely the work with actual papermaking slurries or papermaking machines unless it were necessary to establish a basic concept. Such an extension would have greatly diluted the excellent theoretical and experimental work the University was accomplishing. C. A. Lee elaborated in support of the above, that TAPPI projects should consist of basic work. The paper companies can then apply the results to their own specific applications.

S. Mason commented on some of the work that the University had done on their own initiative and time. He was very interested in their use of fibers in a vortex apparatus, and felt that their suggestion that this might have application to viscosity determinations was worth following up.

Presentation of 1959 Work

Dr. Debler started his summary by describing the modifications on the experimental equipment. The major ones involved an improved flow-approach section, headbox, and slice section. The changes had resulted in better reliability. Measurements with the improved equipment were somewhat different in detail but generally confirmed the earlier test results.

Dr. Debler explained that Dr. Yim had done a considerable amount of related work outside of TAPPI support. He had essentially completed an analysis of the instability of a film of liquid on the outside surface of a rotating roll. The theory included both surface tension and viscosity effects. This work, with TAPPI permission, had been submitted for publication by the Proceeding of the Royal Society by Sir G. L. Taylor.

Reprints of "Free Surface Instability" by Yim and Spengos were distributed to all members. More recent data obtained with the improved apparatus were also presented by Dr. Debler. Spengos thought the new experimental determinations of the rebound phase of spouting differed appreciably from his earlier results and indicated that the earlier region of downward acceleration over the table roll might be confounding the picture. These results would necessitate a revision of some of the earlier thinking. The group agreed that it might be desirable to study an isolated phenomena of upward acceleration in the next program.

Debler indicated their desire to get a better measurement of the height of disturbances. He showed some photos directed at this end and stated that they would give a better appraisal of this approach in his final report on April 1. They would also have results obtained with a larger diameter roll for reporting at that time.

Future Work:

Wrist then summarized the various aspects of flow instability that might be a basis for future work:

A. Continuation of work on spouting on the fourdrinier.
B. A study of streak formation in the headbox slice
C. Instabilities of a non-Newtonian liquid on rotating rolls; "Turkey tracks" from roll coating being an example.

Mason presented a considerable quantity of data obtained from various paper companies that had machine direction streaks of 2.25 ± 0.15 in. There was considerable discussion by Wrist and Lee indicating that many of these cases may have been due to mechanical reasons such as moley roll hole spacing. It was acknowledged that some natural vortex formation in the slice region could account for some of these cases and that an understanding of this phenomena was of considerable importance in slice design.

It was agreed that Items (a) and (b) would be most appropriate basis for new work at this time. Wrist will draft the proposal for next year's work. This will be submitted for A. Yih's approval before final presentation to the parent committee in New York on Feb. 24, 1960.

The meeting closed with a discussion of the side benefits of the project. Foremost was that the project had done much to make the University students and staff aware of challenging technical problems in the paper industry. Debler, himself, had attended the APPA meeting that was concerned with this subject. The spouting apparatus is one of their more spectacular demonstrations and has been of considerable interest to students, staff, and visitors. Dr. Spengos said he would probably not have gone to work in the paper industry if it were not for the interest aroused while working on this project.

C. A. Lamb, *Secretary*

Industrial Engineering and Materials Handling Committee

Minutes of the Industrial Engineering and Materials Handling Committee meeting—15th Engineering Conference held in Jacksonville, Fla. Oct. 26, 1960.

The meeting was opened by Chairman Kendall. Hank Stoess gave a report on the committee meeting in New York in February. For details on his report, please refer to the minutes and cover letter distributed by Hank under letter of March 1, 1960.

Chairman Kendall announced that your new secretary would take over commencing with this meeting and that our new data sheet secretary, Fill Wilson, would also commence with his duties at this meeting.

Chairman Kendall reviewed the program to be presented by our committee at this conference.

Chairman Kendall announced that the 16th Engineering Conference will be held in Washington, D. C. at the Shoreham Hotel on October 15 through 19, 1961. Our program for this meeting has been tentatively set on the following basis:

1. Outdoor Chip Storage and Handling—this paper will cover East and West Coast operations.
2. Wood Procurement and Harvesting.
3. Wood Storage and Handling in Concentration Yards and Mills.

We discussed the regulations concerning preparation of papers with respect to timing, slides, etc. This information will be relayed to the prospective authors at an early date.

Chairman Kendall opened a discussion of subjects for papers for the Montreal meeting in 1962.

a. A paper on data processing was suggested, with Jack Sweers and Creed Reagan indicated to arrange for this paper.
b. High speed photography as a tool for industrial engineering and materials handling.—John MacBrayne has been requested to handle the preparations for this paper.
c. Systems and procedures approach—by Creed Reagan.
d. Economics of bark as fuel, suggested by Fill Wilson.
e. Site selection for research lab. suggested by John MacBrayne.
f. Site selection for paper mills, suggested by Burt Kendall.
g. Typical wastes in mill operation, or "Say it in dollars," suggested by Ed Olmstead.
h. Industrial Engineering approach to cost saving—Fill Wilson to handle.
i. What are we paying for that we are not getting—suggested by Ed Olmstead.

Chairman Kendall headed a discussion of the organization of our committee. Suggestions were made on the basis of subcommittees similar to that in the organization of the Electrical Engineering Committee. Ed Olmstead was quite helpful in this discussion in giving us the scope of organization of some of the other committees with particular emphasis on the Drying Committee. As a result of this discussion, it was decided that our most practical approach will be to organize the committee on a task force basis. You will hear more about this from your chairman and secretary.

In the discussion of Interim Meeting, it was decided to follow the pattern of our last interim meeting and schedule for a full day at the 46th Annual meeting in New York. The last such meeting was held at the Hotel Lexington. It was agreed in our meeting that duplicate plans for the Interim meeting would be most satisfactory. The tentative date for this meeting is set for February 20, 9:30 a.m. at the Lexington Hotel.

The Data Sheets report was made by Creed Reagan. Presently, there are 23 items on the Data Sheets list. A report on Data Sheets will be made by Fill Wilson. Chairman Kendall requested each committee member to submit to Fill Wilson at least one subject for a Data Sheet. Please bear this in mind and submit your suggestion to Fill at your earliest convenience.

A motion was made and seconded for adjournment.

CURTIS E. GREEN, *Secretary*

Industrial Engineering and Materials Handling Data Sheet Subcommittee

Minutes of meetings held during Fifteenth Engineering Conference Oct. 24–28, 1960, Robert Meyer Hotel, Jacksonville, Fla.

Following the meeting of the parent committee, the Data Sheet Subcommittee met, and this meeting was opened with a report by Creed Reagan on the status of various current data sheets and action and status reports are recorded as follows:

1. "Units of Measure Common to the Pulp and Paper Industry." This data sheet was tabled until such time as Don Hall may be present at a meeting. Burt Kendall will handle this with Don Hall by correspondence.
2. "Pulpwood Characteristics." published as Data Sheet 196. To be left out of any further discussions.
3. "Pulp Storage Capacities." Data Sheet Subcommittee secretary to check on publication.
4. "Industrial Truck Specifications." To be put in proper form for submission for voting prior to next meeting. Also to be cleared through the publication, *Distribution Age*.
5. "Industrial Sizes of Noncaptive Pallets." Data Sheet Subcommittee secretary to check on publication.
6. "Salt Cake Storage Facilities." This data sheet withdrawn and to be left out of any further discussions.
7. "Flow Process Spmbols." This data sheet published and to be left out of any further discussions.
8. "Flume Capacities." This data sheet to be distributed and voted on by correspondence.
9. "Waste Paper Storage Facilities." Creed Reagan requested subcommittee members to furnish all available information on storage of waste paper and broke in bales including density, bale size, effect of type of waste, effect of pretreatment such as shredding and chopping, etc.
10. "Pulpwood Characteristics." Because of general lack of interest and agreement that this data sheet could present only obsolete data by the time of its completion, it was agreed that this sheet would be dropped, and it will be left out of any further discussions.
11. "Pulp Volumes vs. Densities." Referred to Herb Teeple and the Pulping Committee.
12. "Unit Weight per Cord of Chips." Because of the unavailability of reliable information, it was agreed that this data sheet would be dropped and would be left out of any further discussion. Subcommittee Secretary will advise American Pulpwood Association of this decision.
13. "Characteristics of Materials Used in the Pulp and Paper Industry." This data sheet will be submitted to subcommittee secretary within one month.
14. "Application of Various Types of Materials Handling Equipment." No assignment.
15. "Lineal Feet of Paper Roll." This sheet ready for circulation and will be submitted by Creed Reagan.
16. "Roll Weights per Inch of Trim/Diameter." This sheet to be reviewed at the next meeting.
17. "Pulpwood Storage Factors." This data sheet dropped and to be left out of further discussions.
18. "Winder Sets per Reel of Various Diameters." To be taken up at next meeting.
19. "Storage Aisle with Requirements." Burt Kendall will handle for the February meeting review.
20. "Chart and Diagram Covering Normal Work Place." This sheet passed out to members for comment
21. "Tractive Effort on Inclines and Ramps." This sheet is ready for submission to the Subcommittee for study.
22. "Factors Affecting Plant Layout." Subcommittee secretary to check with A. P. Schnyder for report.
23. "Standard Performance for Trucks." To be reported on by Jack Schwiers in New York in February.

It was agreed that all data sheets in progress by this subcommittee would be mailed to the subcommittee secretary for distribution to the membership for comments and a preliminary vote by mail.

Burt Kendall requested that each member of the Data Sheet Subcommittee submit one data sheet suggestion to the subcommittee secretary prior to the February meeting in New York.

F. G. WILSON, *Secretary*

Testing Division

Container Testing Committee

The meeting was called to order at 2:00 p.m. Oct. 10, 1960, at the Royal York Hotel in Toronto by the chairman, A. W. Hoffman.

Messrs. T. W. Cadden, E. W. Carney, and R. D. McDaid requested to be assigned to the Committee and all requests were approved by the chairman.

The minutes of the September meeting were reviewed by the chairman and were approved as published.

The chairman introduced correspondence from TAPPI which served to clarify official voting rules for committee section. TAPPI advises that it is permissible to include a nonvoting category on each ballot and that the three quarter rule governing acceptance is to be based on three quarters of ballots received. Further correspondence from TAPPI reviewed by the chairman disclosed that the ring crush testing method is within the jurisdiction of the Container Testing Committee.

SUBCOMMITTEE REPORTS

Flat Crush Subcommittee (*Assignment No. 689*). The chairman of the Flat Crush Subcommittee, Mr. Nelson, distributed the partially rewritten flat crush method for corrugated fiberboard for committee review. Mr. Nelson felt that a cooperative committee effort would be extremely helpful at this time and suggested that the method be reviewed and returned to Mr. Nelson not later than Dec. 1, 1960, along with pertinent comments and/or corrections. It is intended to have this method ready for publication by next February.

In the general discussion that followed the flat crush study, independently conducted by G. G. Maltenfort of Container Corp., was considered. It will be recalled that this committee sent the extra set of flat crush samples, which has been

TAPPI Testing Division, Container Testing Committee: A. W. Hoffman, chairman, Continental Can Co., New York, N. Y.; G. C. Lecky, vice-chairman, F. J. Kress Box Co., Pittsburgh, Pa.; J. J. Kipnees, secretary, Atlantic Gummed Paper Corp., Brooklyn, N. Y.

originally prepared by Container Laboratories, to Mr. Maltenfort for testing on the Concora crush tester. Mr. Maltenfort duplicated Container Laboratories' tests on the new machine and has since prepared a report comparing the results of the two studies. Mr. Nelson read excerpts from Mr. Maltenfort's report and it was apparent that there was some difference in the results achieved in the two studies. In essence the CC of A report suggests that with proper care and maintenance, there exists a sufficient latitude in the choice of machine, sample size, etc. to provide for statistically significant results. Further, the CC of A report disclosed that loading rates had little significant effects on test results. Based on the latter, CC of A suggests a 1.0—1.5 in. per min. platen speed. The proposed committee method on the other hand is based upon loading rates for fixed beam machines. Mr. Nelson recommended that we should publish our work and perhaps include the supplementary study conducted by Mr. Maltenfort. The chairman concurred, clarifying that Mr. Maltenfort's study should be included anonymously as a general activity of the committee. Mr. Nelson will therefore summarize the methods used and will comment on the additional findings of another laboratory. The chairman suggested that Mr. Maltenfort and Mr. Nelson get together on this summary of data to incorporate both studies which will then serve as a basis for a method pending further comments from the committee.

The chairman will further request that Mr. Maltenfort refrain from issuing a public report on his study owing to the fact that his tests were conducted on samples supplied by TAPPI and the TAPPI report has not yet been approved formally.

Mullen Test Subcommittee (*Assignment 691*). E. Knapp, chairman, discussed the progress of the round robin bursting test study initiated during the February meeting. Mr. Balster had sent the experimental diaphrams to the various committee members appointed to participate in this test. Unfortunately the test had not begun because of inadequate instructions.

Procedures will be sent to participants by Mr. Knapp in the very near future.

The balloting tally on the suggested bursting test method was reviewed. While distributed to the total committee membership of 39 only 13 replies were received with 12 of these being affirmative votes and one negative. A great many suggestions were also uncovered in the balloting including the suggestion for a more concise definition of terms.

Mr. Hoffman read a commentary received from J. Clark, chairman of the Standards Committee of TAPPI on the bursting test method. Mr. Clark discussed the procedures adopted in Australia and also offered specific comments on this subject discussed at the Portland Testing Conference. The letter was given to Mr. Knapp for consideration of the comments contained therein as applied to the bursting test method.

The chair asked G. L. Gleeson, a visitor at the meeting, representing the Australian Paper Manufacturers, Ltd., to provide Mr. Knapp with the latest thinking in Australia on this matter. Mr. Gleeson in turn asked for comments on the 20 and 100 lb. clamping pressure suggested in the Australian method. It was agreed that 20 lb. of clamping pressure was too low on domestic fiberboard and that slippage would occur. It is emphasized that domestic testing experience dictated the separation of clamping pressure techniques on linerboard and corrugated board because of the different problems experienced with these materials. Mr. Hoffman mentioned that, on the basis of informal surveys of people attending this and the previous session of this committee, relatively few technicians employ automatic clamping devices today for testing corrugated fiberboard.

Summarizing, Mr. Knapp will incorporate pertinent comments received from Mr. Clark and these will be incorporated where applicable. It is the intent of the committee to develop the linerboard method first and then proceed to the corrugated method. The revised method will be sent to the Secretary who will arrange for this to be reproduced by TAPPI for a subsequent ballot. A reply will be requested not later than December 1, 1960.

Compression Test Subcommittee (*Assignment No. 690*). The Compression Test Subcommittee chairman, Ked Martin has communicated with Mr. Hoffman requesting release from his assignment as chairman of this group owing to the pressure of other activities. A new acting subcommittee chairman, Myron Clark was then appointed by the chair. Mr. Clark will communicate with Mr. Martin to obtain all pertinent papers including procedures and will prepare a new revision of the compression test method which will include all noncontroversial, editorial changes and improvements.

Mr. Hoffman briefly reviewed the major controversial areas of the compression test method including fixed versus floating platens and flap bending procedures prior to sealing.

It was agreed that it is important to stress that the method is intended for referee purposes and in the interest of obtaining a current date for this method the editorial changes will be accomplished and the controversial methods will be subsequently reviewed.

Messrs. Cadden and McDaid were appointed to serve with Mr. Clark on the Interim Compression Test Task group.

Other Activities

In accordance with the directive received from TAPPI Headquarters, the chairman of the various testing division committee has been requested to prepare a letter of appreciation to the management of each committeeman and guest attending sessions. A supply of forms was distributed to those in attendance so that the proper management representative can be contacted by the chair.

A committee roster dated Aug. 1, 1960, was distributed and corrections were requested. A new roster will be prepared based upon the corrections and additions received.

Mr. Hoffman introduced additional correspondence from the Technical Secretary of TAPPI with official regulations concerning the use of metric units or equivalents for all methods.

The Paperboard Testing Committee for TAPPI is currently balloting on a proposed revision of TAPPI method T 403. The group objected to the use of the terminology "paperboard" in the title of the method and Mr. Winchester mentioned that he would check with this group and request the deletion of the term "paperboard" or if this term is common usage in fine paper terminology, the term "paperboard" should be clarified to indicate "other than that used for containers." TAPPI Headquarters subsequently checked this point and determined that no conflict exists. The title of T 403 is "Bursting Strength of Paper" and does not include the term *paperboard*.

C. Root, chairman of the task group requested to review ASTM drop, puncture, and drum procedures reported to the chairman in a letter. Mr. Root mentioned that the ASTM methods have been reviewed and as revised could serve as a basis for TAPPI methods with minor revisions. This matter was referred back to the task group to act on their recommendation. Unfortunately a member of the task force requested to review ASTM standards on conditioning of paperboard and containers was not present. It was agreed that this subject was particularly pertinent because of the work currently being undertaken by other agencies in their investigation of conditioning procedures and a report will be available for the February meeting. The chairman intends to refer the moisture content method to this group for review.

A further piece of correspondence from Mr. Winchester of TAPPI was read concerning the review of methods are: Testing Division Operating Procedures. Our group is currently working on projects 689 "Flat Crush Test of Corrugated Container Board," 690 "Compression Test of Fibreboard Shipping Containers" revision of T 804, 691 Bursting Test of

Paperboard and Paperboard Products," 716 "Definition of Terms Relating to Shipping Containers," 717 "Revision of T 800 m-50 Revolving Hexagonal Drum Test," and 718 "Revision of T 802 m-44, Drop Test for Fiberboard Shipping Containers." The review dates for these were studied. In conjunction with project 716 concerning the definition of terms relating to Shipping Containers, G. Lecky was appointed to review the work of ASTM in this area.

The committee recognized the need to review impact and vibration methods but will await ASTM methods prior to future action.

In conjunction with drop test methods on bags, T. W. Cadden was requested to contact Packaging Institute to determine the extent of that group's investigation in this matter. C. Root was appointed to review drop tests on cylindrical containers and the WVP studies of D-10 as a basis for TAPPI revision.

Mr. Hoffman reviewed a final letter from Mr. Winchester of TAPPI concerning the 46th annual meeting concerning time desired for the technical sessions. The committee respectfully declined at this time.

The next meeting of the Container Testing Committee will be in New York in February.

J. J. Kipnees, *Secretary*

Fillers and Pigments Committee

The meeting of the Fillers and Pigments Committee which was held Sept. 27, 1960, at Grand Rapids, Mich., was called to order by Chairman Willets at 2:00 p.m. with twenty members and visitors present. The minutes of the last meeting in New York City on February 22, were accepted as issued.

The status of projects assigned to committee members follows:

No. 699. Analysis of Calcium Carbonate—George Hall. Approved in principal on letter ballot but should cover both precipitated and natural carbonates. It was also suggested that procedure for moisture determination requires 5 instead of 100 g. because of bulk. Referred back to George Hall for revision.

No. 701. Analysis of Diatomaceous Earth—Herbert Kranich. Project completed—Approved by letter ballot and to be submitted to Standards Committee.

No. 702. Analysis of Synthetic Silicate Pigments—Nathan Millman. Project approved by task group and to be submitted for letter balloting.

No. 700. Analysis of Talc—Mau ice Warner. No report on status.

No. 704. Methods of Slurry Viscosity, Enzyme compatibility, Adhesive Demands, etc.—Paul Plante. No report. A chart was suggested to give the amount of pigment to determine the viscosity of the slurry.

No. 705. Correlation of Test Methods for Various White Fillers and Pigments—W. H. Kreiling. Method for Sampling approved by letter ballot and to be submitted to Standards Committee. In addition to the comments given on methods for brightness moisture, pH and grit, Bill Kreiling asked for suggestions before the February national meeting when he will have a meeting with his task group.

No. 738. Testing of Colored Pigments—Harold Brill. Just prior to our meeting, Harold Brill had a meeting of his task group during which it was decided on specifications for dry colors, pastes and extender colors for both wet end and paper coating. Raw material suppliers of the various colors were asked to submit their tests for color and strength.

Miscellaneous

Abrasive Test for Pigments—It was suggested that the method for measuring abrasive properties of pigments presented by Bob Fraik at the February meeting of TAPPI be submitted as a Routine Control Method.

Specific Gravity Test for Pigments: It was agreed that there is no need for such a method in TAPPI as it is readily available and supplied by pigment manufacturers.

Particle Size Distribution Method (T 649 m-54)—no changes proposed in this method as it shows practical correlation with other particle size distribution measurement methods.

S. J. Batruk, Jr., *Secretary* and W. R. Willets, *Chairman*

Paperboard Testing Committee

The TAPPI Paperboard Testing Committee offers a common meeting ground for the manufacturers, converters, and consumers of paperboard. By their combined action testing procedures are developed that meet the needs of the related industries, and the recognition of these tests by TAPPI promotes their general acceptance and use. In addition, all of the latest developments in testing and end-use requirements.

During the past few years the committee has been primarily concerned with the following tests:

Tearing Test

Because of the problems in making reproducible cross machine direction tear tests, this test method has been studied for revisions in techniques. H. W. Verseput (Continental Can Co.) has been carrying out this investigation and as a result of his work the committee has recommended a tentative procedure incorporating a semicircular die-cut sample in the standard Elmendorf test.

Printing Smoothness

In conjunction with other TAPPI committees, this committee participated in a program at The Institute of Paper Chemistry in which methods of measuring printing smoothness are being investigated. After the Van den Akker-Wink oil-spreading technique was not found to be well suited to this purpose, the project was directed toward the casting of surface replicas under various conditions. Such replicas can then be examined and evaluated by any suitable method. This project is still underway.

Bending Test

The Boxboard Research & Development Association has developed a test method for determining the bending quality of paperboard which is considered very satisfactory by many paperboard producers. The committee has recommended submitting this procedure to TAPPI as a suggested method and this is currently being prepared by Clyde Eckhart (Packaging Corp. of America).

Score Bending

The forces required to bend cartons at their scores has been recognized as a variable in carton performance and W. O. Kroeschell (Michigan Carton Co.) and W. C. Utschig (General Foods) are currently evaluating different methods of measuring this factor.

In addition the committee has been represented on projects initiated by other Testing Division committees. These are Mullen test, tensile energy absorption.

Past work of the committee has resulted in the adoption as tentative standard tests by TAPPI of the Stiffness of Paperboard (T 489), the Water Immersion Test of Paperboard (T 491), and the Water Drop Absorption of Paperboard (T 492). A test to measure the alkali staining resistance has been approved as a routine control method; and a standard procedure for the use of the Vanceometer to measure the gloss ink characteristics of paperboard has been prepared and submitted as a routine control method.

Three new projects were discussed at our last meeting. Preliminary investigation is proceeding on a susceptibility to roll set, to moisture measurement of laminated board and ply-bond strength.

The development and general recognition of standard testing procedures within the industry provide an essential base for inter-company specification and testing. The wide acceptance of TAPPI testing methods is ample evidence of their importance and all segments of industry related to paperboard are encouraged to take part in these activities.

Flexibly Coupled Motor Bearing Design, Application, Installation, and Maintenance Considerations

JAMES F. FENSKE

This paper is limited to general purpose applications involving motors flexibly coupled to centrifugal pumps, motors, agitators, vacuum pumps, etc. The area of discussion is further limited by the request of the committee to study the subject of thrust problems of flexibly coupled sleeve bearing motors—Project No. 789 covers this study.

THE TAPPI Electrical Engineering Committee has been responsible for a number of detailed engineering reports following studies relating to the electrical equipment requirements and problems of the pulp and paper industry. While the majority of the considerations pertain to the electrical characteristics of the equipment, logically, studies pertaining to mechanical characteristics also play an important role in proper design, application, and successful operation. It is with this latter phase that this paper deals . . . the mechanical aspects of electric motors.

This paper is limited to general purpose applications involving motors flexibly coupled to centrifugal pumps, blowers, agitators, vacuum pumps, etc., Fig. 1. It does not cover the special purpose applications involving such equipment as the thrust producing refiners, nor does it cover vertical motors.

The area of discussion is further limited by the request of the committee to study the subject of thrust problems of flexibly coupled sleeve bearing motors—Project No. 789 covers this study.

For the general purpose applications outlined above, the calculation of the *expected* bearing load is relatively simple especially when the motor is direct flexibly coupled to the driven equipment. In these applications the motor need do nothing more than transmit torque through the coupling to the driven equipment. The bearings of these motors, when properly applied, installed, and maintained, will be rather lightly loaded because the radial component of the load is very small compared to the radial load carrying capacity of the motor bearing. In the direct flexibly coupled application, the weight of the motor rotor is usually so small that an attempt to calculate the statistical life of the bearing is made virtually meaningless by the great disproportion between the actual load value and the bearing load capability. To illustrate this point, let us calculate an example involving a 100 hp., 1800 r.p.m., standard squirrel cage ball bearing motor driving a centrifugal pump, Fig. 2. We choose a ball bearing motor for the simple reason that the Anti-Friction Bearing Manufacturer's Association methods for calculating bearing life are standardized and readily illustrated. This is not the case if we were to choose a sleeve bearing motor. Our example calculation will involve a motor in which the coupling end bearing is a Size 313 with a load rating of 4220 lb. at 1800 r.p.m. In this motor the rotor weighs 315 lb., Fig. 3. In this service, the coupling end bearing radial load would be essentially one-half the weight of the motor rotor. The calculated statistical bearing life is over 9,000,000 hr. *minimum.* Practical considerations indicate to us that when such calculations result in a minimum bearing life in excess of 100,000 hr., the number of hours expected life beyond 100,000 hr. is virtually meaningless because of the factors other than those under the control of the bearing manufacturer.

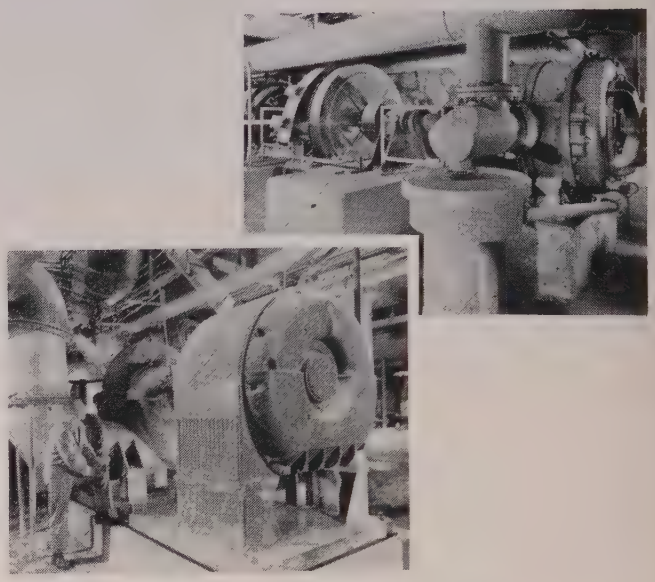


Fig. 1. Typical applications

As previously stated, the calculation of sleeve bearing life is not as simple a procedure as it is for a ball bearing. Theoretically, a properly designed, manufactured, loaded, and maintained sleeve bearing will last forever because the hydrodynamic oil film prevents metal to metal contact and thus no wear would take place. One survey, made several years ago, indicated that, in general, sleeve bearings have a life about twice that of ball bearings. We are all aware that specific installations may not support this overall figure because of the many factors that influence the life of a sleeve bearing.

We have specifically taken the time to make the comments concerning the life of bearings in general purpose direct flexibly connected service to illustrate that *expected* loading is

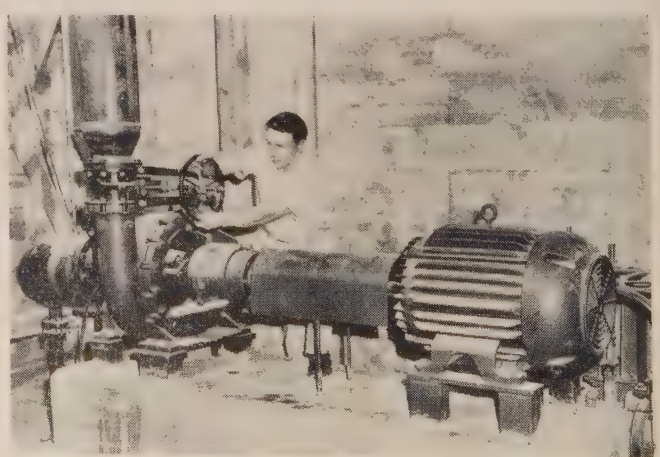


Fig. 2. 100 hp. ball bearing motor driving paper stock pump

JAMES F. FENSKE, Manager, Sales, Electrical Dept., Allis-Chalmers Mfg. Co., Norwood, Ohio.

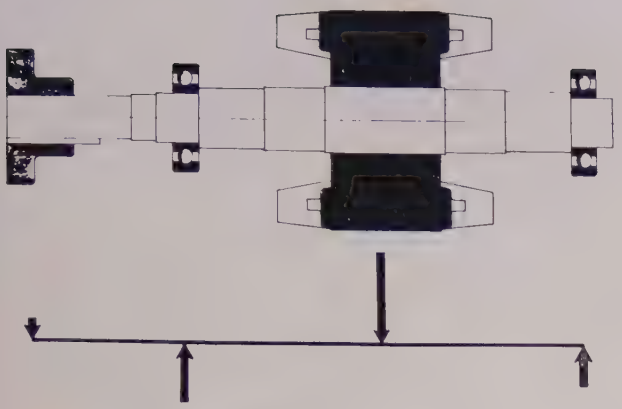


Fig. 3. Bearing load diagram

really very light and thus *expected* loading is not the immediate cause of premature bearing failure. This, therefore, leaves the *unexpected* to consider.

There can be two components of bearing load—one component being radial, and one component being axial. In the general purpose direct flexibly coupled application we have illustrated that the radial component of bearing load is small in comparison to the radial capacity of the bearing, Fig. 4. In such an application, the radial component of bearing

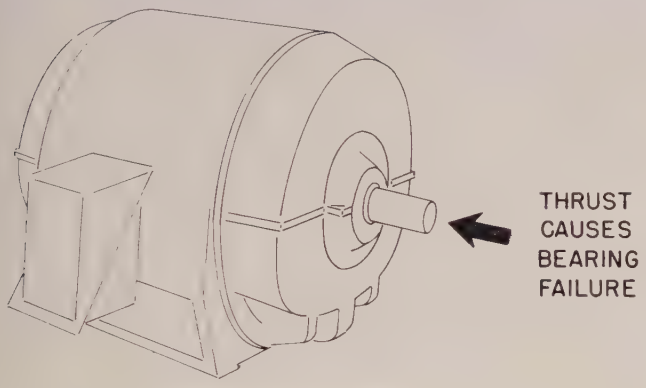


Fig. 4. General purpose sleeve bearing motor

load is no problem to the motor designer. The other component of bearing load, the axial component, in these applications involving a sleeve bearing motor, is an *unexpected* load which can be of significant amount and which can cause considerable difficulty and premature bearing failure.

Let us first examine the general design of sleeve bearings. Sleeve bearings in general purpose motors are oil ring lubricated . . . a good, simple, and proven method of lubrication, Fig. 5. The oil ring, turned by the shaft journal, lifts oil to the top of the bearing where it is deposited in oil distribution grooves from which the journal takes the oil and literally pumps it between the journal and the bearing in the lower or load bearing area of the bearing. The formation of the hydrodynamic oil film between the journal and the bearing is a

Fig. 5. General purpose sleeve bearing oil ring lubricated

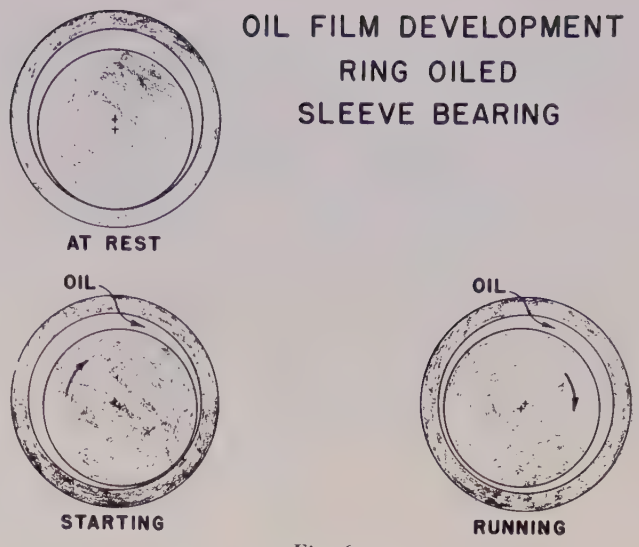


Fig. 6

natural action, Fig. 6. The thickness of this oil film is but a fraction of an inch and depends on such factors as the load, oil viscosity, amount of oil supplied by the oil ring, and journal speed. The oil film is designed to carry the *expected radial* load on the bearing. Design is generally very conservative in this respect. Sleeve bearings not only have a cylindrical surface (bore) for carrying radial load, they also have faces for axially locating the free floating motor rotor in the cylindrical surface of the bearing, Fig. 5. The inclination exists to loosely identify the bearing faces as "thrust" faces. An oil lubricated bearing of general purpose design is capable of carrying only momentary thrust at best.

The designer attempts to keep bearing oil end leakage to an absolute minimum. The faces of the bearing are not lubricated—we do not want excessive bearing oil end leakage to work its way along the shaft and out of the bearing housing and oil reservoir. You can see that when an axial or thrust load is placed on the motor shaft, the motor shaft moves in the direction of the thrust until the shaft shoulder contacts the unlubricated babbitted surface where metal-to-metal contact takes place. If the thrust load is of sufficient amount and duration, the heat of friction will soon melt the babbitted face and bearing failure will occur. In the application, installation, and maintenance of sleeve bearing motors flexibily coupled to driven equipment, *all* sources of continuous axial thrust must be eliminated.

What are the sources of axial load in such an application? The floating rotors of squirrel cage induction motors and

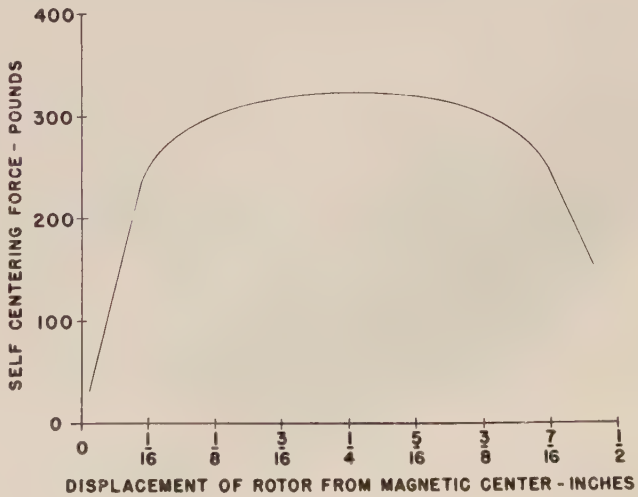


Fig. 7. Self centering force versus displacement of rotor from magnetic center 600 hp., 1800 r.p.m. motor

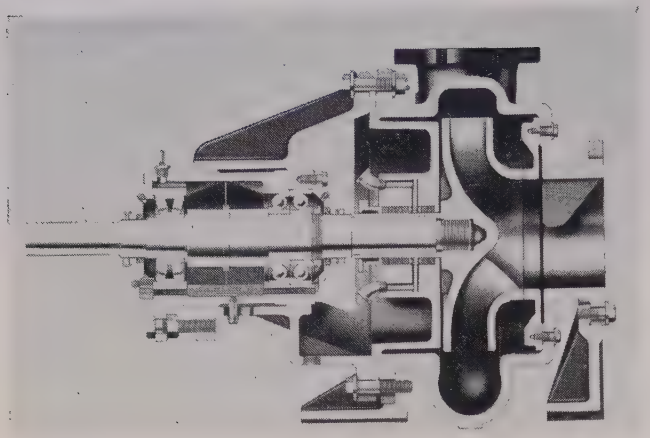


Fig. 8. Typical pump construction

salient pole synchronous motors tend to center themselves in the electrical (magnetic) center of the stator field, Fig. 7. The motor maufacturer designs and builds the motor so that the electrical and mechanical centers are in near coincidence. To achieve this, the motor manufacturer, during the factory commercial test, forces the rotor to float to both mechanical extremes to be certain that when the rotor is floating on electrical center it is very near the mid-point (mechanical center).

Ordinarily equipment such as the centrifugal pump does not transmit thrust because this type equipment is built with thrust bearings to carry any internal thrust which may develop. In the case of the centrifugal pump, the thrust bearings are designed, mounted and built in such a manner that the pump shaft is allowed to move axially no more than a distance something in the order of 0.015 in., Fig. 8. For a properly applied and maintained centrifugal pump, we assume that the pump shaft is essentially locked in place axially. Only in those cases where the bearings are improperly applied or maintained will the shaft be forced to move axially enough to impose a thrust on the motor bearings. In the event of a bearing failure, the shaft can be forced to move axially enough to impose a thrust on the motor bearings.

Axial or thrust loads can be imposed on the motor bearings if the motor shaft is not level. Caution must be used to insure proper shaft level.

Flexible couplings of certain types under certain conditions of misalignment can and do generate axial or thrust forces within themselves, Fig. 9. It is this source of thrust which is often not recognized. New unworn flexible couplings perfectly aligned under normal operating conditions will not generate significant thrust. This is a theoretical hypothesis. Our discussions here must be on a more practical level. With large motors, even the best practical alignment of the free floating-type coupling does not insure freedom from thrust developed within the couplings of this type.

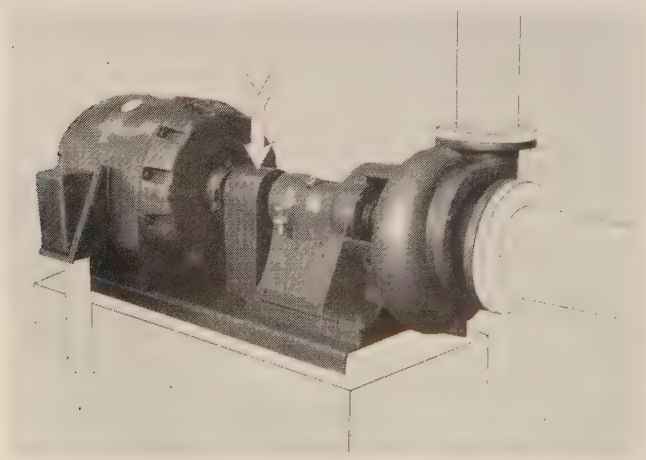


Fig. 9.

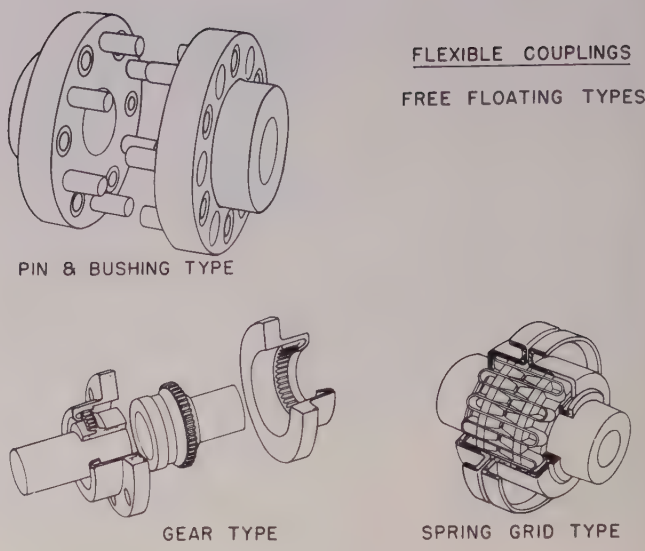


Fig. 10

Without modification, the following types of couplings have unlimited end float and are classed as the free floating type; pin and bushing type; spring grid type; gear type, Fig. 10. Without limited end float modification, the above mentioned free floating-type flexible couplings can, under certain conditions of misalignment, generate thrust forces which will cause the motor half-coupling to move a sufficient distance with a sufficient force to cause motor bearing thrust and motor bearing failure.

To illustrate how thrust forces are developed within a flexible coupling, we shall use the gear type coupling as an example. This is a commonly used coupling and is one which lends itself well to this explanation. The teeth of the mating hub and cover are suppose to be free from wear and the alignment should be such that they are perfectly parallel. If the mating teeth are perfectly parallel, then they will transmit torque without developing an axial or thrust component. If they are misaligned (not parallel), the mating teeth will come in contact in such a manner that will permit the transmission of torque but they will also develop an axial or thrust component, Fig. 11.

With parallel misalignment, as illustrated, the development of forces is as follows: On the driving side, at the 90° position, the hub tooth is sliding along the cover tooth under pressure A. The friction encountered in the sliding action results in a pull on the hub, F_a. Similarly, at the 270° degree position, under pressure B, the friction encountered in the

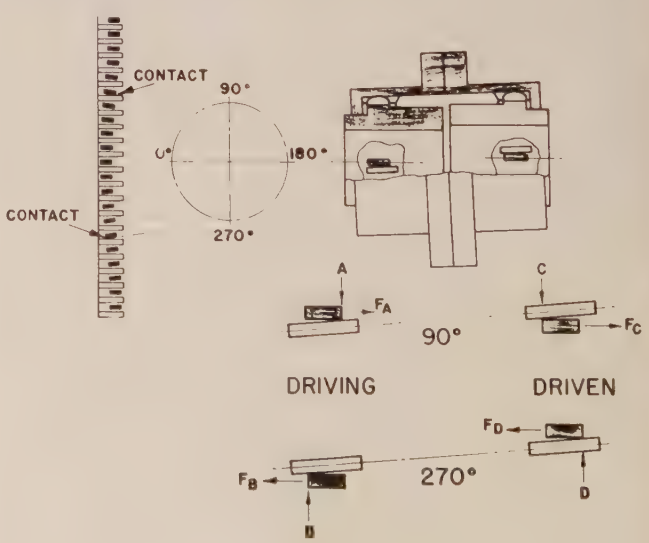


Fig. 11. Development of forces in misaligned gear-type coupling

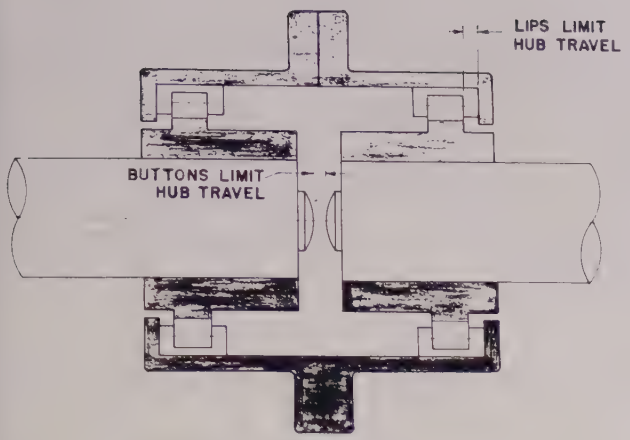


Fig. 12. Free floating coupling gear type l.e.f. modification

sliding action results in a pull on the hub, F_b. Force F_c and F_d are determined similarly for the driven side. The pressure forces A, B, C, and D keep the cover in equilibrium and under *ideal* conditions of uniform clearances these forces should all be equal.

The friction forces F_a, F_b, F_c and F_d will be equal only if the coefficients of friction at all four points of contact are equal. Any variations in coefficients of friction will produce inequalities in the friction forces and result in a net thrust on one or both hubs. Once the friction forces become unbalanced, the system of forces can act to cause further imbalance and a very substantial thrust force can develop. The condition can be further aggravated by differences in the clearances between driving hub and cover and driven hub and cover. Such differences in clearance can be the result of large differences in the press fit of the hubs on the two shafts. The magnitude of such axial thrust developed within the coupling can readily be enough to overcome the magnetic self-centering force of the motor rotor and, without limit of the end float of the coupling, move the motor rotor shaft shoulder against the face of the bearing with sufficient force to cause the development of friction heat which will very shortly lead to bearing failure.

There are several ways to approach the elimination of coupling thrust.

One approach is the complete education and surveillance of those who install electric motors and align flexible couplings. The practical aspects of this approach are well appreciated by pulp and paper industry engineers.

Another approach involves the use of the limited end float coupling. Limited end float couplings are available from several coupling manufacturers. The limited end float coupling successfully prevents axial thrust from being transmitted to the bearings of the motor because the maximum end float inherent to the coupling is less than the total end float of the motor rotor. Any thrust developed which tends to separate the coupling halves is restrained by lips located at the ends of the coupling cover. Thrust tending to bring the coupling halves together is restrained by buttons located in the ends of the shafts, Fig. 12.

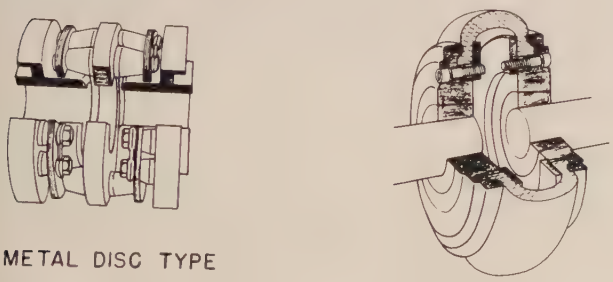


Fig. 13. Flexible couplings—elastic axial centering forces

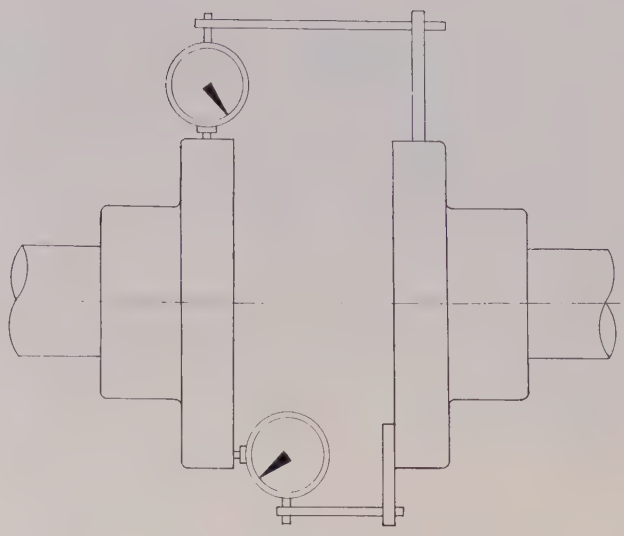


Fig. 14. Arrangement of dial indicators to check coupling alignment

Another approach involves the use of couplings with elastic axial centering forces. The following types of couplings may be used without modification where limited end float couplings are specified: laminated metal disk type and rubber biscuit type, Fig. 13.

Regardless of coupling type, coupling alignment is a very exacting procedure. Coupling alignment checks must be made with a dial indicator. Coupling alignment should be made with the motor and driven unit at normal operating temperature. If this is impractical, compensation must be made for any temperature differential that exists. Mount a dial indicator on the coupling rim, Fig. 14. Rotate both shafts together. Take readings at top and bottom positions. Keep the indicator button on the mark when taking readings. Alignment should be such that at normal operating temperature the difference between the top and bottom readings is not more than 0.002 in. and the difference between the two side readings is not more than 0.002 in. Next, mount the dial indicator on the coupling face. Arrange the indicator so that the indicator button is as close as possible to the outside diameter of the coupling face. Mark the position of the indicator button on the face of the coupling. Rotate both shafts together, keeping both shafts in thrust against their respective bearings. Take readings at the top and bottom positions and at the left and right side positions. Keep the indicator button on the mark when taking readings. The alignment should be such that the difference between the top

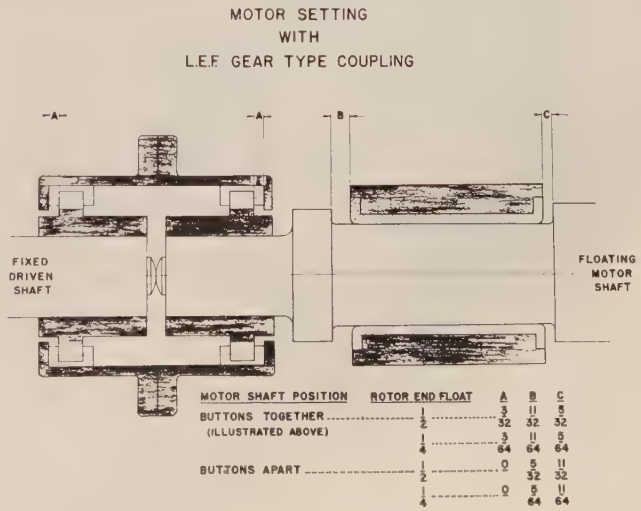
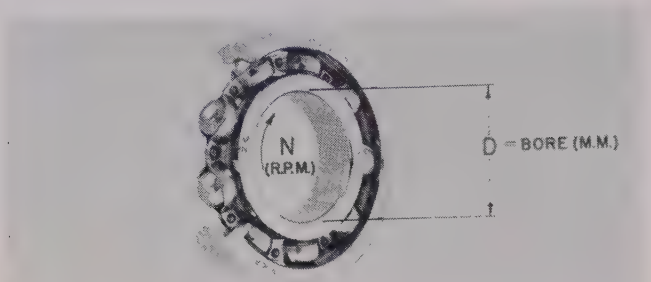


Fig. 15



BALL RETAINER	MAXIMUM D×N
PRESSED STEEL	200,000
PHENOLIC OR MACHINED BRONZE	250,000

Fig. 16. Ball bearing design limits grease lubrication

and bottom reading is not more than 0.001 in., the difference between the two side readings is not more than 0.001 in.

The setting of the motor in relation to the driven equipment is equally as important as the alignment of the coupling itself. The setting must be such that when a limited end float coupling is used, the motor shaft shoulder cannot be brought to bear against the motor bearing face. There must always be some endwise clearance of shaft to bearing under all operating conditions, Fig. 15. The difference between the rotor end float and the end float in the coupling allows for expansion and contraction in the driven unit, for clearance in the driven unit bearing, for endwise movement in the coupling, and for assembly. This setting must be employed when couplings of the gear type, pin and bushing type, or spring grid type are used. When couplings of the laminated metal disk type or rubber biscuit type are used, the motor is set so that the rotor is at the center of its end float (mechanical center).

At this point, we wish to call to your attention the authorized engineering information published in NEMA Motor & Generator Standards Publication, MGl-6.11 (see Appendix). Although the NEMA authorized engineering information is entitled "Coupling End Play and Rotor Float for Horizontal Motors Coupled to Fluid Pumps," on an engineering basis, you can readily see that this information is applicable to a broader line of equipment than fluid pumps.

If sleeve bearing motors require careful consideration in the selection of the coupling and in its installation, why not just use ball bearings in all of our motors? Ball bearings are capable of carrying axial loads in addition to radial loads. We are sure that most of you are aware of the other factors in the selection of bearing type, such as:

1. The horsepower and speed rating of the motor. The Anti-Friction Bearing Manufacturer's Association or the individual bearing manufacturers tell us that there are limitations on the size of grease lubricated ball bearings at any given speed, Fig. 17. The bearing size, operating speed, and lubrication systems are interdependent.

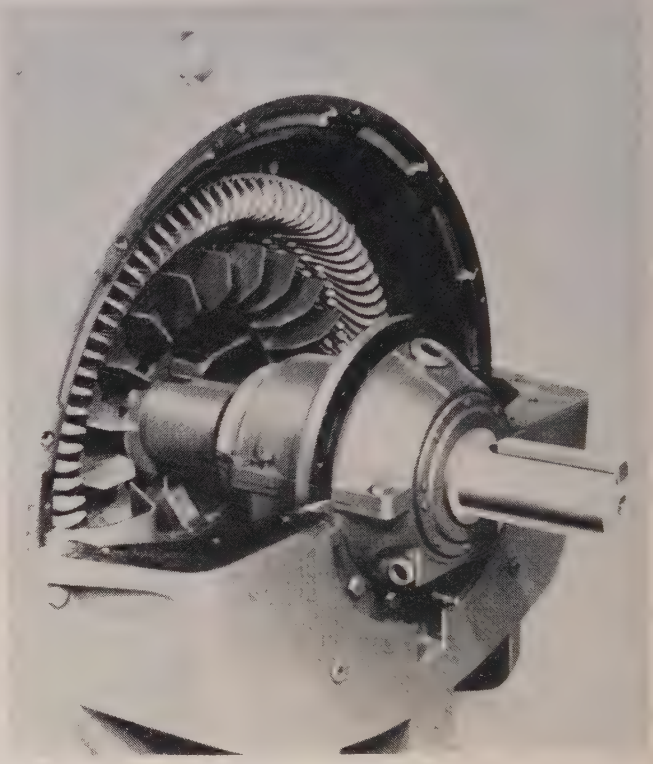


Fig. 18. Stator and rotor accessible for inspection

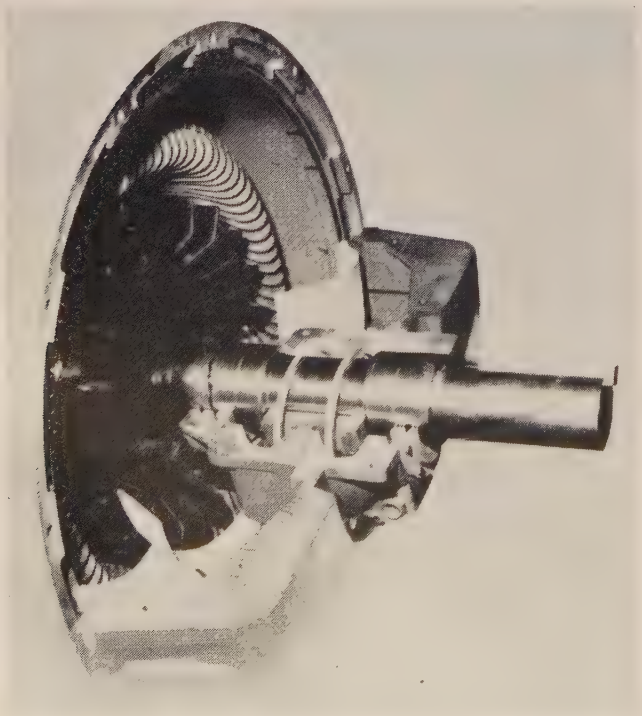


Fig. 17. Split sleeve bearing accessible for inspection

2. Maintenance considerations. The large motors are available with split housing and split sleeve bearings. The split housing and bearing design facilitates inspection and maintenance of bearings without such cumbersome procedures as removal of the motor half-coupling, Fig. 18. Split sleeve bearing construction also facilitates inspection of other motor internal parts, Fig. 19.

Bearing design, application, installation, and maintenance of pulp and paper mill motors requires constant attention. To cope with the problems arising from any one or combination of these factors requires that we first recognize the problem and its source. We trust that this presentation will give you a better appreciation of factors involved in the bearing design, application, installation, and maintenance of direct flexibly coupled motors.

APPENDIX

The following is from NEMA motor and generator standards publication: Coupling End-Play and Rotor Float for Horizontal Motors Coupled to Fluid Pumps—MGl-6.11.

Operating experience on horizontal sleeve bearing motors has shown that sufficient thrust to damage bearings may be transmitted to the motor through a flexible coupling. Damage to motor bearings due to thrusts under such conditions will be avoided if the following procedures are observed

by the motor manufacturer and the pump and motor assembler:

A. It is recommended that motors be proved with ball bearings wherever applicable, particularly for the ratings indicated in the following table:

Motor horsepower	*Synchronous speed of motors, r.p.m.*
100 and below	3600 and 3000
200 and below	1800 and below

B. Where motors are provided with sleeve bearings, the motors bearings and limited end float coupling should be applied as indicated in the following table:

Motor horsepower	*Synchronous speed of motor, r.p.m.*	*Minimum motor rotor end float, in.*	*Maximum coupling end float,[a] in.*
125 to 200, incl.	3600 & 3000	1/4	3/32
250 to 450, incl.	1800 & below	1/4	3/32
250 to 450, incl.	3600 & 3000	1/2	3/16
500 and higher	All speeds	1/2	3/16

[a] Couplings with elastic axial centering forces are usually satisfactory without these precautions.

1. Indicate on the motor outline drawing the minimum motor rotor end play in fractions of an inch.
2. Mark rotor end-play limits on motor shaft.
3. Show maximum lathe center dimension on motor outline drawing.
4. The motor, when provided with sleeve bearings, and fluid pump should be assembled and adjusted at the installation site so that there will be some endwise clearance in the motor bearing under all operating conditions. The difference between the rotor end play and the end float in the coupling allows for expansion and contraction in the pump, for clearance in the pump thrust bearing, for endwise movement in the coupling and for assembly.

Authorized Engineering Information 6-11-1956, revised 11-11-54; 5-17-55.

DISCUSSIONS

J. V. Cundelan, Electrical Engineer, Rayonier, Inc., New York, N. Y. Insulation systems have been so highly developed by motor manufacturers that open type, random wound, and form wound motors are now being advocated and used by our industry in all sections of the mill. The last two AIEE "Pulp and Paper Industry" conferences had very interesting panel discussions on this subject. It was evident to anyone who attended these conferences that the users are very much interested in these new insulations. Perhaps because of this emphasis on insulation research, there are now more motor failures caused by bearing failures than by insulation failures. Motor manufacturers, of course, are not expending capital for development work in this field because they do not manufacture bearings. It is, therefore, the responsibility of bearing manufacturers to develop sleeve bearings that can withstand axial loading; and also the responsibility of the user to select, install, and maintain the proper type of coupling to prevent axial loading from occurring on motor bearings.

One of the major causes of bearing failures is misalignment. The correct alignment sequence for sleeve bearing motors is as follows:

1. Position the motor so that when a limited end float coupling is used, the motor shaft shoulder cannot be brought to bear against the motor bearing face.
2. Level the shaft and plane motor feet.
3. Correct horizontal parallelism.
4. Correct horizontal angularism.
5. Adjust vertical angularism.
6. Adjust vertical parallelism for thermal rise.
7. Hot check with unit coupled.

It may be well to define some of these terms.

A shaft is level if it will coast to a stop without resting against either bearing shoulder when rotated free from the shaft shoulders. The motor feet should be shimmed to obtain this condition.

To plane motor feet adequate shims are installed to ensure equal pressure on each pad, at each foot, or corner of motor. With the use of a dial indicator, and by loosening base bolts, it can be determined if too many thin shims have been used which causes a spongy condition to exist.

Horizontal parallelism is the relationship of the shafts' axes, along the horizontal plane.

Horizontal angularism is the angle or bend formed by the shafts' axes, on the horizontal plane.

Vertical angularism is the same as horizontal angularism except on a vertical plane.

Vertical parallelism is the same as horizontal parallelism except on a vertical plane.

Thermal rise and hot check refers to expansion of the units due to higher than ambient operating tempertaures.

At one of our mills we had a good example of bearing failure due to coupling misalignment. This involved a 350 hp., 3600 r.p.m., squirrel cage induction motor, driving a boiler feed pump. Driving and driven units were connected with a grid type coupling. The motor had recently been reinstalled, after 2 years' service, with new sleeve bearings and a new shaft. After running 4 hr. and 30 min. the motor failed. Inspection indicated that the rotor was frozen tight, the shaft was badly worn at both bearings on the same side of the shaft, and the bearings were oval shaped, both with wear on the same side. It was found that the coupling was very much misaligned. Horizontal parallelism was 0.016 in. and vertical parallelism was 0.010 in. For good alignment these values should be 0.002 in., maximum, in accordance with NEMA MG-6.11 Engineering Standards. I feel that this was caused by not checking thermal expansion of the boiler feed pump as it approached normal operating temperature.

Another of our mills that has had extensive cases of motor bearing failures, due to end thrust, feels that most of its problems are due to coupling wear. This eventually results in misalignment. The problem exists on practically all types of motor driven units. It is aggravated at the higher speeds and is more serious at higher horsepowers; but it is more prevalent on the smaller units, from 1 to 150 hp. due to the larger number of drives in this range and the fact that the smaller sizes do not receive the care and attention given to the larger sizes.

The trouble occurs frequently on the fixed pin with loose disk type of coupling. Pins and disk holes wear on an angle, and as a result, force the coupling halves apart. It also occurs on the spring grid type as a result of the coupling slots wearing at an angle.

Damage most frequently occurring to sleeve bearing motors, due to misalignment, consist of:

1. Wiping the babbitt off the bearing face.
2. Wearing away the face of the shaft and bearing shell.
3. Battering back and forth of the rotor and shaft.

All of our mills report excellent service records with limited end float couplings. On all of our new construction projects, and wherever possible in existing mills, limited end float couplings are being purchased and installed.

R. W. Foster, Chief Electrical Engineer, Champion Paper & Fibre Co., Canton, N. C.

Drive. One 1750 hp., 138 1/2 r.p.m., synchronous motor driving four direct connected vacuum pumps, two Nash L-7208A and two Nash H-7208A having calculated possible total brake horsepower load of 1780 hp. Floating shafts 2 ft. long were used with cast steel rigid and flexible sizes 7 and 8 gear-type couplings. Rigid half size 8 on each motor shaft

and flexible on floating shaft with size 7 in each of the other cases with rigid half on floating shafts.

MISALIGNMENT

West end of motor

Rigid half on motor within 0.003 in. round.

	Concentric	*Parallel face*
Top	+0.003	0
South	+0.017	−0.006
Bottom	+0.050	−0.005
North	+0.035	0

East End of Motor

Rigid half on motor within 0.002 in. round.

	Concentric	*Parallel face*
Top	+0.030	0
South	0	−0.002
Bottom	+0.004	−0.004
North	+0.035	−0.004

All of above readings indicated on motor couplings with "Christmas Tree" on pumps.

Following readings between pumps with dial indication of west and east end pumps and "Christmas Tree" on inner pumps.

East End Pump

	Concentric	*Parallel face*
Top	0	+0.001
South	+0.011	+0.001
Bottom	+0.025	−0.001
North	+0.015	0

West End Pump

	Concentric	*Parallel face*
Top	0	+0.001
South	+0.011	+0.001
Bottom	+0.025	−0.001
North	+0.015	0

The above readings were taken 9-30-59, and the drive was started February, 1959.

The original troubles were noted by examination of bearing oil and discoloration of same. After examination of west motor bearing it was discovered that thrust faces were badly worn but not equal on each end. After considerable checking for shaft currents and checks to see if motor was running at a consistent magnetic center, the bearing was replaced with a new one which failed within several hours and bearing temperature relay operated. The original worn bearing was installed (2 hr. machine downtime).

Motor total end play with control bearing was 1/4 in. It was discovered that magnetic center was very close to one end of this travel, and pedestal was moved approximately 1/8 in. to properly center. Bearings were redesigned to the extent of cutting radial grooves and plugging part of the drain holes so as to force more oil along the thrust faces of bearing.

No further troubles have occurred, but we are wondering what coupling life may be expected with the above misalignment. Inspection after several months operation indicates no further trouble at thrust surfaces, nor do we see any difference in running position.

Normal input to motor is running about 1620 hp.

Conclusion. Alignment tolerances were within 0.003 at installation, but either foundation movement or movement of pumps due to piping stresses caused misalignment on this installation. Motor bearings failed due to lack of complete centering of running center in 1/4 in. end play or lack of enough oil on thrust surface during starting or stopping.

QUENTIN W. HEIN, Supervising Engineer, Research, The Falk Corp., Milwaukee, Wis. Mr. Fenske is to be complimented on his detailed presentation of the thrust problem of flexible coupled sleeve bearing motors. A complete understanding of the factors involved should lead to the elimination of the term "problem" for this type of application. I would like to elaborate on two points mentioned by Mr. Fenske.

1. The axial setting of the sleeve bearing motor relative to the driven equipment.
2. Free floating couplings.

The axial setting of the motor in relation to the driven equipment is important not only to prevent the motor shaft shoulders from coming into contact with motor bearing face, but also to prevent axial forces from being introduced into the system. Under imperfect conditions where the sleeve bearing motor rotor at instant of starting is at an extreme position away from its electrical center, an expelling force is exerted. According to a motor manufacturer, a 600 hp., 1750 r.p.m. squirrel cage motor rotor could thrust toward the driven equipment with a 270 lb. force under such conditions. With a limited end float coupling, this axial force must be carried by the bearings of the driven machine. By following proper installation procedures as typified by NEMA publication MGI-6.11 for limited end float couplings, such axial forces can be minimized. Care should be taken to see that the bearing clearance and other causes of endwise movement in the driven equipment are accounted for in the installation. For example, applying a torque sufficient to rotate the axial floating herringbone pinion of a gear reducer will enable the installer to find reasonably close, the pinion's operating position on its mating gear.

In all flexible couplings that permit end float, the maximum force required to permit end movement is dependent on the transmitted torque in the coupling. This force which tends to resist any endwise movement can be expressed simply as follows:

$$F = uW_t$$

where:

F = force, lb.
u = coefficient of friction
W_t = tangential component of load, lb.

In the above expression, W_t equals the transmitted torque divided by the effective load radius of the coupling. The coefficient of friction is dependent on the degree and amount of lubrication.

External axial forces exceed the frictional axial resisting force of flexible couplings in nearly all power transmission drives. In a special case such as the sleeve bearing motors, the external axial force exerted by the motor under operating conditions can be as low as 1% of the transmitted tangential force. My experience with a 700 hp., 3600 r.p.m. induction motor having 1/2-in. end float showed that the motor rotor moved inward toward the driven equipment on starting. Correspondence with the motor manufacturer brought the following response. "When power is first applied to the stator winding, the high current flowing across the cross tends to make this group of connections act like a solenoid. This solenoid action tends to draw the rotor toward the cross connection end of the motor. As soon as the stator current is dropped to the steady state condition, the rotor will flow back to its normal magnetic center, providing there is no restricting force. Since this motor has a solid rotor, there is no strong magnetic center present." The axial force produced by the motor to center its rotor was equal to or less than the internal resisting force of the flexible coupling which caused the motor rotor to operate part of the time off its magnetic center. Using properly installed limited end float flexible couplings is a practical way to handle special cases as the sleeve bearing motor drives.

J. J. KIMMEL, Chief Engineer, Coupling Dept., Koppers Co., Inc., Baltimore, Md. Since gear-type couplings are normally

provided with some type of securely fastened end rings, they are inherently limiting as far as separating the connecting shafts. The limit of end float of the shafts toward one another is also inherent in the fact that the shafts will butt against one another. The combined value of the inherent end float of the two values above added together is normally greater than can be tolerated by the sleeve bearing motors, and it is therefore necessary to restrict this amount of movement. The most general way of limiting this total value is to separate the equipment and make use of the end rings of the couplings to limit the separation of the shaft ends and provide some means to restrict their movement toward each other. Wherever possible it is recommended that a button be placed in the center of one or the other or both shafts. Caution must be observed that these buttons do not recess into a "shaft center" or be so large that they inhibit the flexibility of the connection between the shafts. It is generally recommended that if there are no shaft centers one button would be sufficient and that it be approximately one-half the diameter of the shaft in which it is mounted. An alternate to this method is to provide a phenolic disk across the center joint of the coupling. This disk would normally have an outside diameter sufficient to fit in the shells or sleeve of the coupling with relief sufficient to allow lubricant to pass across. A phenolic disk is recommended with end float restricted by this method since the outside diameter of the coupling hubs can, if necessary, impress themselves and not unduly restrict the flexibility of the coupled joint between shafts.

When shafts are separated such that either a floating shaft or a spacer is to be used to connect between shafts, then caution must be observed so that the assembly can be accomplished without movement of the connected equipment. For instance, if rigid half couplings are mounted on equipment with flexible halves of couplings on the floating shaft, it would be necessary to put buttons, if they are used, on the equipment shafts or, in other words, in conjunction with the rigid half couplings since rigid coupling halves are normally recessed.

One particular caution that should be observed in restricting end float on gear-type flexible couplings is that there must be some small freedom of the coupling so that it may be properly bolted together with a tight joint and so that the connected shafts still have some flexibility. The minimum amount which is normally recommended would be approximately half the float shown on the NEMA standards for limited end float.

G. C. Werner, Vice-President, Sales and Engineering, Thomas Flexible Coupling Co., Warren, Pa. First of all, I would like to commend Mr. Fenske for his excellent presentation of this topic which has been a subject of much misinterpretation and debate over the past years. I believe this subject is being brought more and more into general understanding by presentations such as this. I am very happy to say I have no point of argument with any thing he has said with the possible exception of the alignment tolerances mentioned. I am quite sure most, if not all, coupling manufacturers would be pleased if their respective couplings were aligned to two or three times the tolerances mentioned.

However, I would like to elaborate on one particular phase of this subject not yet mentioned, namely, the expulsion forces of a rotor on start-up. Every time a motor is energized, there is a strong force tending to expel the rotor out of the stator in an axial direction. As the motor comes up to speed, the rotor gradually drifts back to its normal magnetic position.

During the past several years there have been numerous instances of bearing failures within minutes of the start-up. In practically every instance it was found the rotor had expelled itself to the limit at start-up. The limit, in this case, being when the shoulder of the shaft came into contact with the face of the bearing. At this moment the torque was applied through the coupling and the sliding surfaces within the coupling locked, holding the shaft against the bearing. The inevitable result was the rapid heat and failure of the bearing.

The flexible disk ring coupling can cope with the long term problem of maintaining the proper position of the rotor as described by Mr. Fenske and the short term start-up problem just described. In that this type coupling has no sliding surfaces, it will not "creep" or "lock" when under torque. The axial characteristics of the disk type coupling are such that it wants to operate in the normal axial position. If outside forces tend to compress or elongate the coupling, it exerts a counter-force trying to restore itself to the proper axial location. For small deflections, this force is almost negligible. For larger deflections, this force increases rapidly. The above characteristic of the disk-type coupling is described by NEMA as "elastic axial centering forces." As such, this type coupling meets all the requirements of float restriction and does not require additional lips and buttons. Reprints of NEMA recommendation MGl-6.11 are available and I would be pleased to give a copy to anyone who might be interested.

At start-up, the disk-type coupling will yield to the axial deflection of the motor shaft. The coupling then immediately exerts a counter-force which aids the magnetic pull in restoring the motor to its proper position. Once in position, the combined centering force of the magnetic pull plus the centering force of the coupling work hand in hand to keep the rotor and shaft from wandering against the bearing face.

J. F. Fenske. In connection with several of the prepared discussions presented.

First, Mr. Cundelan comments that motor manufacturers do not manufacture bearings. This is true when speaking of antifriction bearings such as ball or roller type. Sleeve bearings, however, in the sizes which we are considering here, are either manufactured by the motor manufacturer himself or the manufacture is done by a subcontractor who makes the bearing in accordance with the individual motor manufacturer's particular design requirements. The important point is that the motor manufacturer controls the sleeve bearing design whether or not he actually manufactures the bearing.

Mr. Cundelan does mention one item to which we wish to give added emphasis; that is, shimming of motor feet during coupling alignment must be done evenly to keep the motor feet in plane.

Second, Mr. Hein and Mr. Werner have commented on motor rotor expelling forces. It is true that an expelling force will be exerted when the motor is started with the rotor off the magnetic center. We feel it is very important, however, that all understand that the magnitude of the expelling force is a function of the original displacement from magnetic center. The 270 lb. figure Mr. Hein quotes is for an original displacement of $1/4$ in. Down to zero original displacement, the expelling force varies linearly with the original displacement. The smaller the original displacement, the smaller the expelling force. You will note from Fig. 7 that this same motor has a self-centering force of approximately 320 lb. at $1/4$ in. rotor displacement.

The expelling force is a short time duration transient force that can result in a bump on a bearing during the time when the stator winding is carrying the relatively high starting current. The solenoid effect of the winding diminishes rapidly as the current drops to normal running current. With the expelling force varying approximately proportionally as the square of the current, the expelling force, of a motor having 600% starting current, when running will be about $1/36$ of the original expelling force. The nature of the speed versus current curve of most motors is such that the original expelling force is present practically only instantaneously and thus we have observed only a bump on the bearing with a subsequent return to magnetic center. A bump once in a while

constitutes an infrequent momentary thrust which general purpose sleeve bearings can withstand.

One additional point—Fig. 15 illustrates the various positions of coupling and shaft when application is made per NEMA Authorized Engineering Information, MGl-6.11. Please note that with a large motor having $^1/_2$ in. rotor end float, the maximum the rotor can get off magnetic center is $^3/_{32}$ in. This displacement is only 37% of the $^1/_4$ in. displacement figure from which the 270 lb. force was derived by Mr. Hein. At $^3/_{32}$ in. original rotor displacement, the 600-hp. motor to which he refers has 100 lb. expelling force.

It is not our experience that proper installations have been troublesome by virtue of the existence of these expelling forces.

Presented at the Fifteenth Engineering Conference, Technical Asssociation of the Pulp and Paper Industry, held in Jacksonville, Fla., Oct. 24–28, 1960.

Electrical Engineering Committee

MEMBERS of the Electrical Engineering Committee, and its subcommittees, were very busy persons during the recent Engineering Conference in Jacksonville. Activities started on Sunday afternoon, October 23, with a meeting of the Steering Committee with Chairman Sig Andersen presiding. The next meeting of this group will be during Paper Week, next February, in New York.

The entire committee gathered for a luncheon meeting on Monday noon, at which time the various subcommittee chairmen reported on the activities of their groups. Plans for the 1961 Engineering Conference in Washington were discussed, and it was decided to present the following technical program:

Power Requirements of Tissue Machines—C. C. Collins
Equipment Grounding for Safety—J. V. Cundelan
Advantages of Motor Control Centers—L. D. Mower
Comparison of Types of Reel Drives for Converter Equipment —R. J. Minges
Field Experience with Sealed Insulation Motors—Author to be selected.

The committee was very pleased to have as one of its guests M. J. Osborne, chief engineer of Bowaters Southern Paper Corporation, who is also the present chairman of the Engineering Division of TAPPI and a former chairman of the Electrical Engineering Committee. His message emphasized the serious obligation that the Engineering Division of TAPPI and each of its committees has toward permitting the industry to provide a better product at lower cost, so as to earn the continuing excellent support of management.

***Electrical Engineering Committee.** S. Andersen, Chairman, W. Va. Pulp & Paper Co., New York, N. Y.; E. G. Parrish, Vice-Chairman, Crossett Paper Mills, Crosset, Ark.; H. A. Wright, Secretary, Allis-Chalmers Mfg. Co., West Allis, Wis.*

***Electrical Engineering Steering Committee.** Standing Left to Right: H. A. Wright, Allis-Chalmers Mfg. Co., West Allis, Wis.; S. Andersen, W. Va. Pulp & Paper Co., New York, N. Y.; G. E. Shaad, General Electric Co, Schenectady, N. Y.; C. L. Harvey, Elliott Co., Ridgeway Pa. Seated Left to Right: R. F. Sorenson, St. Regis Paper Co., Jacksonville, Fla; E. G. Parrish, Crossett Paper Mills, Crossett, Ark.; M. M. Stokely, J. E. Sirrine Co., Greenville, S. C.*

Mr. Osborne used as a basis for his discussion the recent letter which he received from Paul C. Baldwin, vice-president of Scott Paper Co., which was published in the September, 1960 *Tappi*. Mr. Osborne suggested that the Electrical Engineering Committee consider as their principal objectives the following items:

Lower construction cost
Eliminate over-motoring of drives
Personnel training

Each of the various subcommittees held individual meetings during the first few days of the conference.

The Electrical Engineering Committee has scheduled an interim meeting at the Pittsburgh Airport Hotel, with subcommittee meetings to be held on the afternoon of April 11, 1961, and the main committee meeting on Wednesday morning, April 12.

CECIL L. HARVEY, *Publicity Chairman*

Questions and Answers

(1-2/61) *Questions:* **What are the pros and cons of using capacitors for motor surge protection? What are the criteria for using this extra protection? At what horsepower should they be applied? Why should they be placed at the motor terminals?**

(2-2/61) *Question* **(Size of Conductors): What size of conductors will be required to transmit 1600 hp. at 0.75 power factor 15 miles with a loss of 7% of the power generated in the line; the circuit to be three-phase with 11,000 volts at the generator, conductors spaced 36 in. apart? Also, what will be the per cent regulation?**

(*2.1-2/61*) *Answer:* With 11,000 v. at the generator, the voltage to neutral of a three-phase circuit will be 11,000 ÷ 1.732 = 6350. Assuming 15% regulation, the volts E to neutral at the receiver end of the line will be 6350 ÷ 1.15 = 5520. The watts W = hp. × 746 = 1600 × 7.46 = 1,193,600, and the current, I, per wire, when the power factor is 0.75, is $I = W \div 3E \times$ p.f. = 1,193,600 ÷ (3 × 5520 × 0.75) = 96 amp. Allowing the loss in

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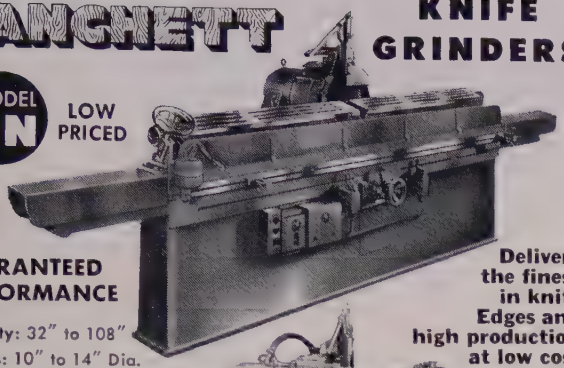

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the line to be 7% of the power generated, the watts loss per wire is

$$Wn = \frac{W}{3} \times \frac{0.07}{0.93} = \frac{1{,}193{,}600}{3} \times \frac{0.07}{0.93} = 2 = 29{,}947$$

Resistance per wire = $Wn \div 1^2 = 29{,}947 \div 96 \times 96 =$ 3.25 ohms; and the resistance per mile is $3.25 \div 15 =$ 0.217 ohm. The nearest standard wire is a 250,000-circ. mil. conductor, which has a resistance of 0.2253 ohm, making the total resistance of one wire equal $0.2253 \times 15 = 3.38$ ohms. With conductors spaced 36 in. apart, the inductive reactance in ohms, at 60 cycles, per mile of single 250,000-circ. mil. conductor is 0.626, making a total of $0.626 \times 15 = 9.39$ ohms.

Knowing the receiver voltage E, the generator voltage Eg is found by the formula,

$$Eg = \sqrt{(E \cos\theta + IR)^2 + (E \sin\theta + IX)^2}$$

where R is the resistance ohms and X the reactive ohms of one conductor, and θ the angle corresponding to the power factor in the circuit. For a power factor of 75%, $\cos\theta = 0.75$ and $\sin\theta = 0.66$. Then

$$Eg = \sqrt{(5520 + 0.75 + 96 \times 3.38)^2 + (5520 \times 0.66 + 96 \times 9.39)^2} = 6370 \text{ v.}$$

$$\text{Per cent regulation} = \frac{E_g - E}{E} \times 100 = \frac{6350 - 5520}{5520} \times 100 = 15\%$$

This value is close enough for all practical purposes. There is no direct method of making these calculations. A certain per cent regulation is assumed and the calculation made. If this does not come close enough, another value is assumed and the calculation made again.

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REPORTS AND DISCUSSIONS

Presented at National and Regional Conferences

High Yield Pulping

Fourteenth Alkaline Pulping Conference
August 22–24, 1960

Introduction by DAVID WETHERHORN: At the last session of the Alkaline Pulping Committee's sponsored technical program for this morning's session, we decided that due to the great interest shown in high yield pulping, we will put on a panel discussion rather than have a paper presented since there seems to be a wide divergence of the proper way to produce high yield or as far as that goes, what is considered high yield. So Eric Rice, our moderator for this morning, has agreed to take over the duties of setting up the panel and I think you will find this very interesting and, as we do not plan to complete all of the items that are listed on your program, if you feel that you would like to have additional information, we will have another panel discussion concerning this at a later date in one of our meetings, either in New York or the fall conference. We would appreciate your expressing an opinion. So without further ado, I should like to turn the meeting this morning over to Eric Rice of St. Regis Paper Co., Jacksonville, Fla.

MR. RICE Mr. Chairman, gentlemen, I believe that high yield pulping has rapidly become one of the most controversial subjects in the pulp and paper industry today. I have had a considerable background with it at Bathurst Power and Paper Co., Red Rock, Ont., and now at Jacksonville, Fla. In having a panel discussion like this, we will accomplish one of two things; either we will leave here so confused that we will drop the subject forever or we will pick up some pertinent facts that will enable us to go ahead a little further in a logical manner. As I see it today our principals in all these different companies are looking at the million dollars a year savings in yield or in wood consumed. This reverses itself back to the woodlands, and their plans for delivering wood to the mill. The wood consumption shows no appreciable difference from time to time and management wants to know what's wrong with this high yield pulp. To help us in this discussion we have on my extreme left John Hart of St. Lawrence Corp. in Montreal. He has had varied experience in high yield kraft pulping and high yield sulfite pulping and considerable work in this field at the Pulp and Paper Institute of Canada. Next to him we have Bruce Ellen of Continental Can Co. in Port Wentworth, Ga. Next to him we have John Henderson of Crown Zellerbach Co., Camas, Wash. and Franklin Jones of Fernandina Beach Container Corp., Fernandina Beach, Fla. Last, on my left is Lloyd Goodwin, pulp mill superintendent, St. Regis Paper Co., Jacksonville, Fla.

The first question I would like to ask the panel to see if we can get any sense from it is do you think we can arrive at a definition of high yield pulp? I will ask Mr. Hart to start to answer that.

MR. HART: High yield pulp, I would say, is any pulp that requires some mechanical work to make it acceptable to the papermakers. In other words, if the pulp can be blown and made readily acceptable as is, it is low yield. If it requires some mechanical fiberizing to make it acceptable, then it is high yield.

MR. RICE: What is medium yield?

MR. HART: Medium yield would be still something that would not require mechanical fiberizing to make it acceptable. It's all whether it is low yield or medium yield—I would say there are two categories, one that requires fiberizing and one that doesn't.

MR. RICE: Another question I would like to ask the panel is by what method, permanganate or chlorine, do you feel is the most reliable to control the cooking? Mr. Ellen, would you like to comment on that?

MR. ELLEN: Well, as far as we are concerned we have not been in a position to use chlorine numbers. Actually, what we have done is to use a 75 ml. permanganate in all of our control work.

MR. RICE: Lloyd, do you have any comment on that?

MR. GOODWIN: We have used both at Jacksonville and I believe we have about come to the conclusion that the chlorine number seems to be more reliable.

MR. RICE: I have here this question of wood usage. There are different mills claiming various yields. Franklin, would you like to comment on what you consider a reliable method to arrive at what yield is in the mill?

MR. JONES: Of course, the most reliable method would be to weigh your wood and weigh your pulp, and, of course, everybody is not able to do that. We aren't able to do that. We have no way of weighing the wood charge of the digester so we actually go more on wood usage than we do on yield so to speak. Our wood consumption is in the order of 1.41 units per ton on board as shipped off the end of the machine. Some people, of course, actually have weight data to go on but we do not.

MR. RICE: Would you like to comment on this, Mr. Ellen?

MR. ELLEN: We are in a little better position as far as that is concerned to try to determine yield percentage-wise because we do have a weightometer on our chip belt feeding the digester and of course being a one machine mill and not having any outside, you might say box ends or anything of that sort coming into the plant, everything that we normally do is based on pounds of chips going to the digester in terms of board coming off the end of the machine, so as far as using a cord per ton figure, it is possibly a little bit erroneous because a lot would depend on just how you were scaling the wood. I know in my own experience our scaling procedure has been changed about two or three times in the last four or five years, which, of course, directly effects the number of cords per ton. However, as long as you stick to pounds of wood being loaded to the digester and also based on the tons of board off the machine itself, over a period of six months to a year, we feel like you can get a pretty accurate per cent yield based on bone dry chips.

MR. RICE: What does the panel feel is the most reliable high yield figure that has been quoted in the industry?

MR. GOODWIN: In our own instance, I would say the order of 54 to 55%; now, some of these other gentlemen may have different figures.

MR. ELLEN: What was the question, Eric, what per cent?

MR. RICE: Yes. You have heard various reports in the industry of as high as 60%. Sometimes it has come out a little higher. Can we pin that down at all or is it going to just float around 53% or as Lloyd says, ours is 53%, maybe 55%. What have you experienced as your highest?

MR. ELLEN: Actually we at one time were up in the range

of 60 to 62%. Of course, we are cooking two different types of stock at the present time. We are cooking softer stock on our top sheet than we do on the base. Right now we are running in the neighborhood of an average of around 60% on the base stock which we consider high yield.

MR. RICE: One thing of interest to everybody is that many mills when you went into high yield pulping, the mill was built for it and you weren't able to compare the mill after you started on high yield with what you did before. I am speaking of Bathurst and probably Port Wentworth and some other mills. In Jacksonville, we have a situation where our machinery will allow us to go up and down. We have found that when you try to go too high you run into trouble in the mill. Your savings in wood may start to show up but your machine operation falls off. Then we can back down in yield a little bit and compare our mill operation which improves. This is one of the points that got me started on this high yield. Just how far are we going to push this thing? We have to look at the overall mill picture as well as the wood savings. In regard to chemical consumption, Lloyd, would you are to comment on that, on the fact that we have been up and down the ladder a number of times?

MR. GOODWIN: Yes, we started out in the range of a 42 to 45 permanganate number using in the order of 13½% active alkali, both based on moisture-free wood. At the present time we are in the order of 12½% active alkali based on moisture-free wood.

MR. RICE: Any other comments? Franklin, would you care to comment on your experience?

MR. JONES: Well, nothing in particular; our yield, like I say, is based on cords of wood as opposed to the weight which we think is subject to some error. In your remarks as to whether or not it was reliable, I think it would hold true with us. We think we are probably in the order of 58% plus or minus depending on the wood error. As far as chemical consumption is concerned, we are probably in the order of 10 to 10½% active alkali. We have noted a number of interesting things on high yield over the past several years. In the initial stages of high yield pulping I think a lot of consideration was given to some of the side effects. For instance, the evaporators and recovery operation I think has certainly been effected a great deal by high yield and I think a lot of people were surprised to get into so many amplifications of the thing. That's a little bit off the subject I realize there, but it is a very important phase of the thing to consider—not all gravy by any means.

MR. RICE: Mr. Henderson, do you have any comments that brings up to date anything you have done? I believe it has been mostly in research, hasn't it?

MR. HENDERSON: Yes, what we have done is quite strictly in research and we have not had the luck in the chlorine number that some of the others seem to have had. We still prefer permanganates at the moment.

MR. RICE: What would be the aim of the West Coast on the type of wood you have here, in talking of yields? What is the density of the wood?

MR. HENDERSON: Generally, we talk in terms of about 24 or 25 lb. of dry weight per cubic foot of green volume. Some other woods run higher, some are lower. We have got quite a variety of woods out here in the west and it will run anywhere from 20, 22, on some of them, up to 28 or better on others, but it certainly is not the high density pine we encounter in our southern operations.

MR. RICE: The panel has been asked by Roy Miller, St. Regis Paper Co., Pensacola, Fla., when does high yield become semichemical? The prefix "semi" implies the boundary lies at the point where the material at the digester contains 50% screenings. Would the panel care to comment on that? Mr. Hart, would you comment on it?

MR. HART: Well, it is the 50% screenings, is that arbitrary or a suggestion? I think that high yield or semichemical are synonomous. If you are going to have to do some mechanical work on the pulp, on the whole pulp, not just part of it, to make it acceptable then it is high yield or semichemical.

MR. RICE: Mr. Ellen?

MR. ELLEN: I just started to say that we feel as far as semichemical is if you get about 65% yield, you're getting into semichemical range and actually, roughly maybe 10% below that, in the 55 to 65% range in yield, we have always considered as high yield. That's just a personal thing as far as we are concerned.

MR. HART: But you put all your pulp through your refiners, your 60% or 58% yield?

MR. ELLEN: That is correct, yes.

MR. HART: So that all the pulp is treated in high yield. If you only treat the rejects then it would not be high yield.

MR. ELLEN: All the high yield pulp, pulp and rejects as far as that is concerned, is high yield. A minute ago, when Eric was talking about the upper ranges or upper limits of high yield and how high we had been in various plants, I think at one time possibly we got up around 62% and possibly still do on our base sheet and in stopping to try to think actually what was the limiting factor as far as high yield was concerned in mill operation, normally I would say that we feel that our washer operation is probably an indicating factor when we get up in the range of 62%, of course your rejects as such begin to mount up. When we get up to where 25 or 30% of the material going across the washers becomes rejects, then we feel like it's time to begin to back off a little bit, although we have no particular problem of handling it after the washers, your ratio of pulp to chips begins to get out of range and first thing you know you're liable to end up with all of it in the vat and not be able to pick it up on the drum because it gets too clean.

MR. HART: At the yield of 60 to 62% do you find that there is any strength drop? How does the stiffness and the mullen keep up?

MR. ELLEN: Actually, I don't think we see any particular drop in mullen as far as that's concerned. I think that actually how you refine and treat this stock has more to do with it possibly than anything else. We don't notice a great deal of difference between, you might say 58 to 62% range, as far as mullen goes on the machine. It may take a little more refining but in the end as far as the machine operation is concerned, we don't see that there is a great deal of difference.

MR. HART: When they get the projector here I have a slide that was taken from a paper that was published in 1958 showing the strength relationship to yield and I am just looking at the copy of it here and it would seem that the maximum strength seems to be somewhere around 52 or 53% yield, but at 60% there is not too much of a drop. In other words, from around 60, 62% down to the 50% yield the mullen doesn't seem to be effected too much. It's when you go to yields higher, about 60 to 62%, that the mullen falls off very rapidly.

MR. RICE: Question from Hans Sonntag, Crown Zellerbach. How much can the yield be increased without seriously interfering with the paper or board strength and specifications? I wonder if we could let that go on till a little later until we get around to the paper machine. This other question from Bob Fayland of Gulf States Paper, what is the highest or the lowest basis weight sheet made from high yield? Do you drop off yield as you drop basis weight? We will put that off until we get to machine operation. Question from J. K. Dyer of Bowaters, does the soda loss decrease as less chemical is used in the digester? Lloyd, would you care to comment on that?

MR. GOODWIN: That has been somewhat our experience; However, there have been other factors contributing to the drop-off. We have gone to high yield in the order of 54 to 55% through the medium of shredding the chips. We have found that our losses off the washers have decreased since we started this procedure.

Mr. Rice: Mr. Jones, Mr. Ellen, could you comment on your soda loss experiences?

Mr. Jones: Well, it depends a great deal, I think, on what you do ahead of the washers and how you do it. We use claflins presently ahead of our washers and we have found that we can and do wash down regularly around 30 lb. soda loss off our last stage washers which is not too bad. We, of course, do our ma'n refining after our washers, which is the case now in several of the mills who originally refined primarily 100% in the pulp mill ahead of the washers. We have found though that our soda loss is not materially effected as a result.

Mr. Rice: Mr. Ellen, do you have any comments?

Mr. Ellen: I would say that it has been our experience or at least we feel that we probably get less soda loss on high yield than we used to. Now it may be that we have just tightened up our system since going on it. Actually when we went on high yield or started into this high yield program in 1954, of course, we put in additional washing capacity and also evaporator capacity because at that time we were considering the possibility that we might have to go to hot stock refining. We started out with refining following the washers to see what would happen, what it would do, we were not sure whether it would be successful or not, so consequently we based our washing capacity on what at that time was known about hot stock refining. Consequently, we ended up with a little excess washing capacity and actually we are washing down to a little lower per cent solids than we were previously and at the same time we feel we are getting a little cleaner stock. Now in all probability it's because we have the excess washing capacity and evaporator capacity.

Mr. Rice: Mr. Borlew has a question for Mr. Hart. A numerical delineation between high yield and semikraft is necessary? Fifty-three to 62% high yield and above 63% semikraft. Permanganate or chlorine number? Kappa number seems to be applicable according to some mill tests.

Mr. Borlew: It is very important that we don't confuse publications and literature and don't confuse semikraft when we mean high yield kraft and vice versa. By experience so far high yield kraft didn't go above 62. The highest was Port Wentworth and Bathurst and it was about the highest we ever met. And in one publication of "Limerick" the highest was about 62. Am I right?

Mr. Rice: I believe so.

Mr. Borlew: Port Wentworth practically confirmed it. Now, we know if we go to semikraft we can use much less active alkali and have to put in much more refining so we might as well get order in the scales here and say up to there it's high yield kraft and there from it's semikraft. Now we also have to define the lower limit of high yield kraft and that would be rather easy because we know if we need refining capacity in the pulp mill that's when high yield kraft starts and it's more or less at $52^1/_2$ or 53%. Am I right?

Mr. Rice: I believe so.

Mr. Borlew: I think we should have a definition of high yield.

Mr. Rice: Yes, that was my first question.

Mr. Borlew: Now the other question about chlorine and permanganate. As you well may know I am an alumni of the chlorine number. We did have very good results at Fernandina which doesn't mean that the same would be in any other mill. There are certain difficulties. The personnel has to be specially trained and it is more convenient to run the permanganate number, but I have found out recently the Kappa number has very little use in high yield kraft and I am wondering whether the Kappa number will not replace the chlorine number. It gives all the advantages of the permanganate number definition and still presents a linear relationship between lignin content and between chlorine number so I would suggest that mills who are now running the chlorine number or mills who are running their own permanganate number should run a few tests in parallel and establish whether they get correlation or not between Kappa number and high yield.

Mr. Hart: The Kappa number I believe does give a very good relationship to yield all the way up and I understand it is up for consideration with the international standards right now.

Mr. Borlew: But not for high yield.

Mr. Hart: No, but it will give you a linear relationship all the way up.

Mr. Borlew: The Kappa number is preferable to the 25 ml. and the 40 ml. TAPPI permanganate number in that zone of doubtful permanganate number between 18 and 22. You have that linear relationship and you know where you stand.

Mr. Rice: Gentlemen, I don't want to remain on this subject too long and I don't want to get in too deep. We might be able to come to the conclusions later on after we have covered the main subjects. Question from Coman Rothrock of St. Regis. How many companies have developed a relationship among chlorine numbers and permanganate in yield. Could such data be collected and pooled in a TAPPI survey report? I certainly think it could be done and I suggest we make a note of that and get some committee to take that on as a TAPPI project. There are at least two ways to accomplish high yield, change the cooking time or temperature or to change the active alkali. George Hansen of Weyerhauser is asking is there any advantage in strength to keep the active alkali high and varying the cooking conditions. Bruce or Frank, would you care to answer this?

Mr. Jones: Well, we have found in our experience that there is no particular advantage in keeping your alkali high. I would think maybe it would be a disadvantage to do that. We feel that there are certainly two ways of doing it; one is to modify your cooking time and the other is the alkali. We do a combination of two, sometimes through necessity. I see no reason why we can't as it has been done many times and is being done to attain strength characteristics which you desire through a combination of time and chemical charge to the digester.

Mr. Hart: There must be a minimum below which you cannot move your alkali.

Mr. Jones: Oh, yes, there are certain limits and there also would be a limit to which you can go at any time.

Dr. Henderson: In the lab we have established in our laboratory equipment quite definitely that the higher alkali is definitely superior to lower alkali and we also feel we are better off to cut the time and hold the temperature. To cut the temperature you are going to start running into troubles. I think that in the long run you find that the equipment used in every particular application can often overshadow these operating conditions of alkali and temperature. When you start comparing one piece of equipment to another the changes can be just tremendous.

Mr. Ellen: Along that same line, I would like to make a comment or two. When we started out we made a series of exhaustive cooks on high yield before we ever got around to going into it. Actually we felt that from those tests it was more or less a combination of time, temperature, and alkali or all three that could be juggled and it was not a problem of just cutting any one. Actually we used to cook pressures of 110 lb. on our digesters but we would end up cooking at 100 which is not a great deal of change. We would go down as far as 90 and come back up to a 100. Actually on that active alkali on the high yield sheet we are running now about 440 lb. per ton. We have felt that it is a little bit better to keep our active alkali up in our digesters and try to get our yield without reducing it too much for the simple reason that we got into quite a pit of evaporator trouble at one time from one thing or another and we always felt it was the extremely low active alkali situation in the black liquor Of course, in bleach mills and soft cook mills, you are going to run into that situation a great deal but we felt that it was certainly to our advantage to try to keep the per cent active alkali in our black

liquor up to at least the 18 to 20% range. Consequently we, in all of our thinking, have aimed at that particular phase because we didn't want to have to go back and add caustic to the black liquor for an efficient operation on the evaporators so we might as well go ahead and do it in the digester. Also, we felt we would just naturally get a better cook and better yield and everything else from it. We feel that it has borne itself out because so far, as long as we keep that per cent active alkali and black liquor up around 18 or in excess, we don't have any evaporator trouble whatsoever. Let it get down though and we are headed for trouble.

Mr. Borlew: Just recently in the mill we had the same experience. All of a sudden due to the fact that we are using a rayon liquor for salt cake makeup which is rather acid, we experienced our black liquor going down to a pH of about 9 and our cooks were delayed by 10 hr. because that active alkali which we were adding was used up by the black liquor, apparently to neutralize itself and to get back to where it belonged to a pH of about 11.5 so this is a very pertinent circumstance.

Mr. Rice: We have a question here from Eric Gest of B. C. Forest Products, Crompton, B. C. Do you favor sulfur addition for sulfidity control? If so, at what point in the process and is anyone using H-factor regularly? Also, what about ultraviolet absorption of black liquor during the cooking as a means of control? Since this question of sulfidity has been brought up again, John Hart will take over the discussion in a few minutes with a few slides. I would like to comment on this. At Bathurst we had high sulfidity and it was felt that it added to the strength of the pulp up in that high range. I believe Southern Paperboard or Continental Can does the same thing. However, in Jacksonville on the 1000 ton per day machine where we have been playing with high yield pulp, our sulfidity has stayed around 20 to 26. We have never purposely tried to put it up to any extent and yet all through these programs of chasing after high yield we haven't seen any great effect from not doing something with it. We have had fairly good tests from the machine and I think other factors that would hurt the machine were more important in our case than sulfidity. However, I wish John Hart would take over now and show the slides on the effect of sulfidity.

Mr. Hart: Well, before I do I would like to comment on the H-factor. At East Angus we are using the H-factor but it is not for high yield. They also have a moisture meter on their chips and they are getting the dry weight of wood to the digesters and sometimes the schedule has to be changed somewhat for production reasons and they are experimenting with the H-factor using first of all the Bristol meter to record it. They are now trying out a Foxboro and they are also calculatng the H-factor by hand on the cooks and they expect to have a paper ready for the January meeting in Montreal on the use of the H-factor. I might add that they have been getting the permanganate number of their blows very close. The limits are getting closer all the time in uniformity. As far as the sulfidity is concerned I have picked out a few slides and a few comments from a number of papers that were published when I was at the Institute over the last several years. Some of the co-authors are here in the audience so they know more about it than I do. It is not very extensive because sulfidity is a large subject and to go into it in any degree is going to be quite a problem. (Now showing slides) This is a slide on yield that I was mentioning a few minutes ago. It is taken from a paper that we published on high yield kraft a couple of years ago on spruce. The charge is of alkali with 17% effective alkali, roughly 18% or so active alkali on the moisture-free wood. The yields were obtained by cutting off the cycle and the strengths are reported after beater tests at 300 freeness. You will notice that up to 60 to 65% the yields are reasonably the same. From 45 to 60% there is not a great deal of difference in the mullen burst at 300 freeness. Now if we could have the first of those large slides. This was taken from a paper that was given by Claude Christensen in 1957 and it is on the sulfidity of the pulping of western red cedar and it shows the effect of increasing the sulfide charge on the moisture-free wood with varying amounts of active alkali and you will notice as the sulfidity is increased the yield goes down from sulfidities of around 2% up to 6% on the wood. That is for each effective alkali charge, the yield goes down slightly. With the lower charges the top solid circles are 13% effective alkali. There is quite a difference as the sulfidity increases. With the very low charge of around 11% which is the marginal, there doesn't seem to be too much of a relation. There are 15% and 17% effective alkali charges between 2% sulfidity and 6%; there is not a great deal of effect on the yield. Now the chlorine numbers follow those general trends that would be expected. Now the next slide that I have to show is from the same paper and it shows the results of a number of cooks where time of digestion is the principle variable. The effect of both alkali charge and sulfide charge is studied with respect to the rate of solution of lignin and carbohydrate. By following these changes in the pulp composition of the lignin-carbohydrate relationship to yield, the effect of sulfide charge was demonstrated on the Ross diagram. Those triangles are for straight soda cook with no sulfide at all and where you add 3.75% of sulfide or 5% the open and solid circles the curve goes to the right. In other words, for say a 5% residual lignin you get something about 5% increase in yield by adding 3.75% of sulfide charge. That is roughly somewhere around 25% sulfidity if I am not mistaken—20 to 25%. When we first made this study we expected that by adding small amounts of sulfide we would get a whole series of curves between the two but that was not the case. If you haven't got enough sulfide the NaOH takes over and you have pretty much a soda cook. When you have enough sulfide you move over in the other direction and when you get increases beyond approximately 2 to 5% sulfidity you don't get much change in composition of the pulp. In other words, there seems to be a maximum amount of sulfide required and increasing that doesn't give you much difference in pulp composition.

Now the next slide that I have here is the rate of change of pulp composition. The "z" on the far size is the per cent of lignin over 100—lignin we assume the pulp is composed of, just lignin and carbohydrate and as you continue to pulp the lignin and carbohydrate will be removed from the wood in a different rate so that any time you stop the pulping reaction you will have a composition of lignin and carbohydrate. They both don't follow down the same rate. The yield in the bottom is the lignin plus the carbohydrate and so that if you take this "z" as a factor, it gives you the rate of the removal of lignin or pulp. This slide is a plot of the log of the lignin-carbohydrate ratio, the "z" against the cooking time and you will notice that for a straight soda cook with no sulfide the top line has a uniform rate of delignification of pulping all the way down for various times. As you add different amounts of sulfide at two different effective alkali charges there seems to be two rates, the first one in the rate is more rapid and then it tends to parallel the soda rate of the pulp after that, and the change in rate is roughly equal to a point about where 50% of the original wood has been pulped or used up. The first indicated solution rate is primarily confined to lignin and is speeded up by the addition of sulfide. That first rate is lignin solution and increases as sulfide speeds it up and the solution of carbohydrate will be less due to the shorter exposures to the alkali solution. Damage to the undissolved carbohydrate should be less for the same reason.

Another paper we presented on using this same technique on the pulping of jack pine and spruce, poplar and birch, the general results indicated that the wood constituents were removed in proportions similar to the amounts present in the original wood. The last slide I have here is data that were collected over a number of years, most of it was published by Dick Scrap and myself quite a few years ago and we put this together to show the experimental results that we had. Along

the bottom is effective alkali in per cent charge. On the left is the per cent sulfide as a per cent charge on the wood and then these lines are various sulfide and we drew a line down between what we call refinable pulps or high yield, anything that requires some refining of the total pulp and on the right hand side are pulps that could be blown and processed without any refining. If you will note at the bottom the heavy line goes very rapidly to the left as you add sulfide. You can get a 15% charge of NaOH in a soda cook that will give you a refinable pulp, whereas if you add sulfide to it, say 13% or 10% sulfidity, you can go to a 14% effective alkali and not get it. (I still get a slush pulp.) That is about all that I had to mention on sulfide except that there is no question that you need sulfide to give you a good product and in the high yield you need this minimum amount of sulfide on the wood, I would say from our results, in order to get a good acceptable product that sulfide is somewhere in the vicinity of 2½ to 3% sulfide on the moisture-free wood.

Mr. Rice: Thank you, John, for that discussion on sulfidity. Is high yield kraft pulping being bleached as a general practice? If so, is the high yield still obtained and does the bleaching cost remain low enough to make it attractice? Anyone care to comment? I am afraid we are not qualified to answer that question. I don't believe it is being done to any extent commercially. The next question is what is the freeness of high yield pulp to the machine in comparison to regular yield pulp? How does the freeness and drainage on the machine compare? I would like to leave that until a little later. This question from Mr. Borlew to Mr. Hart—there seems to be an optimum for mullen at 57 to 58% according to unpublished research. Please comment on the moisture meter for wood. Is it the hydrotester?

Mr. Hart: Yes, I believe it is the hydrotester.

Mr. Rice: Let us move on into the mill were we get to the screening operations. Lloyd, do you care to comment on the screens that we are using?

Mr. Goodwin: Yes, we are using the Cowan screen Mark A, primary screens, and the Mark A for the secondary, and one of the juniors for the tertiary in our system.

Mr. Rice: Franklin, would you care to comment on the effects of screening in high yield pulp?

Mr. Jones: We have the same trouble everybody else has to find a screen. High yield is a very difficult material to screen effectively. We in our plant have no. 5 Impco centrifugal screens and also we have the new A-44 Impco screen which is somewhat comparable to a Cowan and we are able to put through a no. 5 in the order of 135–140 tons per day. Through an E-44 we can put in an order of 175 tons. Some of the mills on normal yield are putting it in the order of 25 tons per day more through the A-44's than we are, but with a high reject count we certainly have more of a screening problem than you would in a lower yield. Our experience has been that we can tell in our screening room immediately if a cook is not what we want it to be. It is a little harder than normal and we can tell immediately if the screens are beginning to load every time. We don't care what the chlorine number says, we know when we get it and our plant uses the chlorine number by the way as a means of controlling the degree of cooking.

Mr. Rice: This is a question I would like to have somebody answer some day. When the lab says the chlorine number is 12 and the screen room operator says it is 15, who wins? Bruce, would you like to comment on the evaporator operation or the recovery operation from the high yield point of view?

Mr. Ellen: As far as our evaporator operation is concerned, Eric, we see very little difference now from what we had before we went on high yield and, of course, there again we were pushed pretty well to a capacity and at the time we went on high yield and put in another set of evaporators, primarily because we felt that we were going to get a lower per cent solid liquor to the evaporators which actually we are doing. We were running in the neighborhood of 15% solids from the washers whereas at the present time we are running around 13½%. Of course, we would never have been able to run this low a per cent solids without additional evaporator capacity. At the same time we went on high yield we upped our tonnage in the neighborhood of 100 tons per day so that was another reason actually that we needed additional evaporator capacity. However, we find very little difference so far as fouling is concerned. Normally we used to boil out a set of evaporators every wire change for the simple reason that we did not dare to do otherwise and we got caught here—between the wire was a dirty set of evaporators with only a single set. We were in the soup so now actually, of course, with the two sets we do almost the same thing. We just boil a set out every other wire or actually one set every wire which means that a single set will run through normally two wires which is roughly two weeks. Sometimes more, sometimes less. As far as we can tell as fibers going to the evaporators, we do not make any attempt to screen our black liquor. We notice very little difference now in the amount of fines or fiber going to the black liquor than we did before. As far as evaporator discharge is concerned we are still running about the same per cent solids. On the recovery furnaces we did not do anything to increase capacities because primarily we felt that with the lower pounds of solids per ton of pulp or board that we would have sufficient capacities to up the tonnage 100 tons and still be able to take care of it on the recovery furnaces. Actually we had dropped our pounds of solid per ton from around 3000 lb. down in the neighborhood of 2200. Right now because of the little softer top sheet that we are running we are up in the neighborhood of 2300 to 2350. We are still able to maintain our maximum tonnages with the resin recovery units. Actually on the recovery units themselves we find very little difference in our operation now from what we did before. Of course due to the lower solids per ton we will get less steam per ton from the units but as far as the overall operation, we find very little difference now than normally.

Mr. Rice: I am going to ask Lloyd to comment on some of the experience he has had where we have been able to change the per cent yield.

Mr. Goodwin: Our experiences have been somewhat comparable to Bruce's. We have gone up and down the range in high yield and we have regrouped and started over again but we have not had the fouling to too great in extent that Bruce has spoken of. At the present time overall solids are running in the order of 2500 to 2600. We have decreased our alkali charge to the digesters on the base stock which has meant a slight reduction probably in the recovery load which has helped us in that particular department.

Mr. Rice: Anybody else on the panel like to comment on the recovery or evaporator operation? Are there any questions from the floor on these two parts of the mill. Before we leave the actual cooking part of the system, Coman Rothrock has asked what are the times to pressure, time on pressure, and pressure used by the various mills. Could we start from the end of the panel and come across with those answers.

Mr. Hart: I am quoting from memory but I think at Red Rock that their cooking conditions are about a little over an hour to pressure.

Mr. Ellen: As far as our cooking is concerned we take roughly an hour and a half to get up to pressure which is 100 lb and then normally 30 min. plus or minus 5 min. at pressure, a total of about 2 hr. cook.

Dr. Henderson: In our experience this varies quite a bit with the digester again. The shape of it, the height, the diameter, ratio, and the way you inject your steam. We have turned out 60% yield cooks in 60 min. and a 110 lb. maximum pressure. In other digesters this goes anywhere up to 60–45 or 90–45% so it varies considerably with your equipment.

Mr. Jones: Before I say anything about the cooking I

would like to comment just a moment on the evaporators. We have noticed sometime back that in boiling out we have particularly hard water. In our evaporators we found a lot of pluggage and what we have done to eliminate that is simply to use the dirty combined condensate from our evaporators. We have a tank and we dump it in there and, of course, let it overflow at all times and then when you get ready to boil you boil out with condensate and we have completely eliminated any pluggage of evaporator tubes by do doing and I imagine other people have done the same thing but it is an interesting point. As far as our cooking conditions are concerned, we have 4300 cu. ft. digesters and we come up to pressure in 45 min. and on pressure 1 hr. 15 min. and we cook at 105 lb. pressure and steam to 341 °F.

Mr. Goodwin: At Jacksonville we take 60 min. to pressure, 30 min. on pressure, and reach a top pressure of 110 p.s.i.

Mr. Rice: To wake up some of these refiner people sitting in the back of the room, I would like to diverse from cooking and that phase of it right now. As far as I know, there are about four or five different types of refiners being used on so-called high yield pulp. The experiences that we have had have been very interesting. I have felt for sometime that there is still a need for refiner plates to be developed for high yield pulp but just how far they could go I don't know. Would anybody like to comment on refiners?

Dr. Henderson: We have several refiners in our operation at Camas lab operation, but they do happen to be a 411–800 hp. Bauer, 500 hp. 362 Sprout and a few others around so we have some full sized refiners and there is a definite difference between these refiners and the lab refiner that you have. Again it depends on your method of operation. In one that is the high speed, refining seems to be far superior. It will give you better mullen development in the early stages and retain your tear better. If you are going further down the line it often appears to be better to drop off to a slower speed refiner and it will develop you on down on the lower end where the high speed machine seems to drop off in cases, but this varies from one wood species to the other all over the map. It is a terribly complex field.

Mr. Ellen: So far as our refining picture is concerned, of course we only have one type. Frankly, we feel that one of the keys to this high yield pulping is in the refining. When we started out we started out with the idea of refining following the washers for several reason. One is that back when we were looking at high yield in 1952 or 1953 the hot stock refining, there were no such things I guess as pressure refining. Everything was a gravity system and frankly, they created one whale of a lot of foam. Washing following the hot stock refining was quite a problem; tramp metal was also a problem to a lot of people and this was the reason we went on to a trial of refining following the washers. There were two schools of thought in the company because no one knew how this was going to screen. Of course, in the first place some people thought that it would so-call "curl" the stock and you would never be able to screen it; on the other hand, some of the others felt that possibly we would get better screened pulp than we would on hot stock. I, frankly, was in the middle. I didn't know what it would do but we were all willing to go ahead and try it. Actually, what we started out with was a plug-type pre-breaker ahead of our washers to break up fiber bundles and the larger chips so we could try to get a pretty decent job if washing. Following the washers we stored in the high density chest and then from the high density chest we pulled out directly to 362 Bauer refiners. We had one whale of a lot of trouble with stock feed to the refiners to begin with and also plate design. It was one of those things that came gradually, it certainly would not come overnight. It took us about two years from the time we started to actually get down to the point where we felt like we had our plates evaluated sufficiently to give us what we were actually after, which as an ultimately high yield pulp to the machine and at the same time be able to refine it enough to screen it. We battled this plate deal around back and forth as I said for two years and to the tune of I guess maybe 50 or 75 different accommodations of plates. Of course, at that time as far as plate design was concerned they were still thinking in terms of semichemical refining which needed a breaking area to a great extent before going to the refining area on plate. Actually as far as our pulp was concerned, we found out pretty quick that that wasn't the type of thing we were after. We finally ended up with a plate that had very little or no breaking area as such. We ended up with a plate on the—well, I guess on our swing head on the stationary portion of it there was a rather large bar with shallow depressions in it or so-called dimple plate design and a fine bar-type plate on the runner. Actually, this gave us what we were looking for and are still standardized with. We have found that to our sorrow we could definitely do something to the pulp in refining in the pulp mill that they couldn't do anything about in recovery on the paper machine. We found that actually we were coming off our washers at a freeness of around 860 to 870 which is based on a 3 g. Schopper Riegler freeness test and if we got down in the range 810 to 815, we just couldn't get any tests on the paper machine whatsoever. We finally ended up with a freeness of roughly 825 minimum. Usually we will run 830 to 840. There is a rather fine line in there we have found, between being able to screen this stuff and try to still maintain a freeness high enough to get it to the machine so they are able to do the work that they want to in the jordan room. Actually, as long as we keep up in the 830 to 840 course, as some of the other boys pointed out, if you get beyond that and get into this heavy fiber there is no question range, we have no trouble whatsoever in screening. Of about it, your screen goes to pulp in a hurry. Actually though, in our normal stock when we are normally in that range, we will get less than 1% rejects coming from the screens. Actually, I think we could possibly dispense with them if we had some sort of screening ahead of the machine itself. We are feeding our refiners in the neighborhood of $4^1/_2$ to 5% for the simple reason that we feel the higher we can get the consistency feed the better off we are and the less work we are doing on water. We had so much trouble with our feeding arrangement going to the refiners that we finally ended up with a spare claflin club refiner idle so we piped the stock through this club-type refiner and set it on zero setting just barely touching on the bars and ran all of this stock through this club-type refiner before we even went to the disk-type refiner. This eliminated just about all of our troubles with feed for the simple reason that it reduced all of the remaining knots and rejects that we had had trouble with plugging our feed valves to practically nothing and we were able to get a decent flow. Along with that I might say we changed from an overhead gravity type feed to a pressure type coming off underneath the floor where we could keep some pressure on our feed valves and as far as our troubles with refining, feed and everything else concerned, we just about eliminated them from that point on. In answer possibly to one of the questions a minute ago, we put our stock in the machine to the jordan room just about the same freeness that we were before we ever went to high yield. Actually, we find there is very little difference in the freeness now and what it used to be. While I am on this thing, I will get off of it permanently. Somebody has asked the question on the advisability of doing all of the refining prior to washing as against doing the refining before and after the washing. I am not quite sure what he means by all of it—are you talking about all of the washing and not doing any of it in the jordan room or rather ahead of the refiner? You mean during the entire refining of the washing. Frankly, I don't know. I don't know how you would wash it if you did it all. If you got it down slow enough to take care of your machine needs, I am not sure how you would wash it. I think if you could reduce your washing capacity it would be nice for the washer people.

Mr. Hart: Would you screen it before washing, after refining and what would you do with the rejects? Would you thicken them?

Mr. Rice: While we are on this subject of refiners, would the panel again start at the last and quote the total horsepower days per ton required in the various mills just to give us an idea of how it can vary. I mean by that including everything after the blow tank.

Mr. Hart: At Red Rock their stock from the blow tank goes through a Claflin just to break it up. I don't know just what power they use there but it is relatively little. It then goes to the washers and from there to Sprout-Waldron and they use about 5.2 hp.-days per ton in the Sprouts.

Mr. Rice: How about the total down in the paper mill? What is the total overall for the paper mill—about 11 to 12?

Mr. Hart: I believe so though I don't have that.

Mr. Ellen: On our base stock, now I am speaking just of high yield, we are using the club type breaker ahead of the washers which is requiring in the neighborhood of around 1.4 to 1.5 hp.-days per ton and then we are going to the disk type or Sprouts but you are running comparable to John's figure of around $4^3/_4$ hp.-days per ton and on down in the refining in the jordan room itself we are running somewhere in the neighborhood of $8^1/_2$ which will give you roughly about 14.4 the way I figure it in horsepower days per ton total on that so-called high yield stock. Now that is not figuring anything for our softer stock.

Mr. Jones: We use approximately 118 kw.-hr. per ton on our brown stock and approximately 203 kw.-hr. per ton on our white stock or a total of approximately 320 to 325 kw.-hr. per ton total.

Mr. Goodwin: On our primary stock no. 2 machine we have claflin pre-breakers. We are running somewhat over 1 hp.—day per ton for pre-breaking, about $1^3/_4$ hp.-days per ton after washers for refining and about $5^1/_2$ to 6 in stock preparation.

Mr. Rice: That low figure is based on 1000 tons per day where they are using Bauers up in the pulp mill and Double D's on the paper machine. Question here, is there a paper color problem due to high yield pulping. I believe this is so although there have been various reasons put out as to what causes it. Some mills are overcoming that problem by cooking the top liner or outside sheet for the top as a very soft pulp to keep it light and the bottom you will notice on a high yield sheet will tend to be on the dark side but there is a color problem in high yield pulping. I believe that is correct. Are there any refiner suppliers here? Would they like to ask any questions of the panel? Let's see what the various opinions are on the quality of the end product. In other words, the sheet that comes off the paper machine as effected by the different ranges in yield. John, could you start commenting on that?

Mr. Hart: Well, I don't know how it is effected by the various ranges in yield. Their yield at Red Rock, according to the pulp mill, is about 56 and according to the wood department, about 54, and we always have a bit of trouble in getting the ring crush test up to meet the standards. Now, just whether that is a quality of yield or not I am not certain.

Mr. Rice: To carry on with the comments in regards to the end products in regard to changes in yield, Bruce, would you care to comment?

Mr. Ellen: As far as our end product is concerned it is going to be a little difficult to evaluate possibly, but what we are doing now and what we were doing before we went on it for the simple reason that we made several changes on our machine that may or may not have effected the end product. Actually we feel that we are getting better end products now than we were before, one thing being primarily we are not having to use any additives in our stock in order to get tests which we were doing prior to getting on high yield but there again it's hard for us to evaluate just how much of this came from the changes that we made on our machine. Actually, as far as drainage rate is concerned we see very little difference now than what we had before because we are putting stock to the refining room at practically the same freeness that we were before when we were on regular board stock so actually as far as the machine is concerned and the machine refining is concerned we find there is very little difference except that it possibly takes a little more power now to get what we want than it would previously. Of course, as far as color is concerned, we were on 100% high yield and naturally we got slightly darker board although now our high yield is still running in the neighborhood of 18 to 20 points brightness on a portable brightness tester. Actually, we never would get into too dark a color on our board and I have always felt that it was probably because we weren't hot stock refining. I may be dead wrong but I have no way of telling, but still and all that is our feeling. Of course, as I say, now we are cooking quite a bit softer stock on the top sheet. As Eric has said before, a lot of people have been forced into it on account of color changes and the fact that we are now thrown in with a couple of other mills in the company and we pretty well have to match up our sheets as far as color and appearances are concerned on account of box plants using our board interchangeably with other plants' board. Actually, our top sheet right now is running just about the same as our board was when we went on high yield.

Mr. Rice: Frank, would you like to comment?

Mr. Jones: Yes, insofar as the end product is concerned I think you can produce the same thing using high yield pulp as you can low yield if you have the equipment to do it with. You can certainly do the same thing. We get what we consider adequate physical characteristics in our finished sheet and the main thing that we have noticed as has been pointed out by Bruce, that the sheet is somewhat darker as you would expect from a normal or lower yield pulp. We are running in the order of 18 Photovolt brightness and we are presently installing soft top liner at our mill to offset the color disadvantage. The color disadvantage I think is primarily brought about the the other sheets in the field being somewhat lighter and somebody says they want this and when they want it you have to give it to them. It is that simple. But as far as the physical characteristic is concerned, we think it comparable to anybody else making kraft linerboard.

Mr. Rice: In the Jacksonville mill we have gone up and down the scale without noticing too much of a problem with the product. There is one thought I would like to inject in this discussion. Apparently from what we have seen, when you start to climb up around 55 to 60% yield, the refining tends to create fines so that your machine will have a poor drainage rate and you will have effect on the drying and sometimes have to lose speed on account of it. Now in pushing this a little further, I am just opening this for ideas. We are getting to the point where the lignin casing around the fibers on high yield is brittle and when you get up in that yield and start to refine it, instead of dehydrating the fibers and fibulating them, you are just breaking them up and creating a fines problem.

Mr. Hart: I have two questions. One is by Mr. Borlew. Literature seems to attribute high yields to polysulfite pulping which would contradict the statement that sulfidity lowers yield. Well, if you take certain effective alkali charge of any given amount, say 17% with no sulfide in it at all, and you add sulfide to that, keeping the effective alkali constant, I think you will lower the yield somewhat by keeping the effective alkali constant and as you increase the sulfide the yield will tend to come down slightly. That is keeping all other things constant. The length of the book, the temperature, the time and everything. The quality of the pulp though, of course, will change as well. The other question, what is the grade on which you are having trouble meeting the ring crush test and what is your specification? I don't know exactly the specifications but the grades are in 42 lb.

and lighter linerboard but it is not as much a pulp question as it is a papermaking question.

Dr. Henderson: I have a question here from Mr. Griffin concerning an article on reject refining and related to high yield also in that we said that improper defibering has led the strength losses of 50 to 70%. If you use a set of refiner plates that are not suited to your job and this can vary with every job again, you can get too much cutting. In many cases this happens with blades that you would not think would cut and you will simply cut the pulp up and reduce the freeness and develop nothing in it. We have tried a great deal of refining techniques and we find that the higher consistency we can get up to a certain point, let us say there is an optimum in most cases of refining consistency. In a great number of refining cases, this runs anywhere from 8 to 20%. We normally prefer to operate at 10 to 12%. We found we can hold our refiners very steady plus or minus 5% maximum ammeter swing on some of these refiners and very good operation overall. We get higher and we start hitting some problems athough we are solving those all the time. We like to carry in our refiner pressure, I would say, on a pad of pulp, just for an example now and I am not pushing machinery please, with our Bauer refiner we have a hydraulically loaded machine where we are able to vary the pressure on the heads, we definitely know that we are floating the heads of the refiner on a pad of pulp when we are getting our very best operation. This means that we have got to put high feed rates through those things to maintain this condition. If your feed rate falls off, the heads come together suddenly and if you get a little too much water in there, the heads come together and the pad breaks. We utilize every ounce of power we can get on the refiner. This, of course, varies with the size of your disks, the plate area and that which you have on a given refiner and so forth. The rotational speed has an effect. But in general at Crown we are heading toward more horsepower on more refiners and pushing as much through them as we can get through the machine. We seem to be obtaining some very substantial quality improvements. Some of this is being tried in some of the mills now. We take nominal clearances in some cases but in most cases, we don't care. You just have to feel your way in each particular case and find out where the optimum is, such as some people have already done.

Mr. Rice: The question has been asked by Paul West and no doubt there are other people in the room who are wondering what our answers to this question will be. The question is what has been the effect of chip shredding on yield, quality, strength, cleanliness, alkali requirements, power consumption, etc. At this stage of the game, after 8 months we do not know the answer to all these questions. We have trends coming along and I think St. Regis will be in a position a year from now or when we have the next alkaline pulping conference to give a paper on the whole story of shredding chips. I am not trying to dodge the issue, but we are just getting into somewhat we don't know all the answers to yet. Question from Roy Miller of St. Regis. Do any of the mills use hardwood in their base stock, how much, and what is the effect? John, could you give us an answer?

Mr. Hart: We don't use hardwood in our base stock. In Red Rock it is mostly 80% spruce or balsam and about 20% jack pine. The hardwood is used on the secondary headbox only.

Mr. Ellen: We are using up to a maximum of around 7% hardwood in our base stock. We are using it in base stock only. We are not using any on our top side. The main reason, of course, we are using hardwood is not for anything good particularly that it does us, but it is primarily because we cannot get out of it. Woodlands forces it on us and says you have to use it so we use it and we put it where we think it will do the least harm. This is about the way it goes with us. Of course, I know none of you have had that same experience but we would try it on the top side also and frankly, because we do have a longer and softer cook on the top side than we do on the base, we felt like it would possibly give us less change and variation if we used it in the base and also because our volume on the base side is running around 80% of our total production so we felt like we could hide it there better than we could anywhere else.

Mr. Hart: I would like to just correct what I said a few minutes ago. Of course, a small amount does get mixed in but we have at Red Rock a semichemical Pandia unit as well and we try to put the hardwood to that and some of that stock is used in the base liner, but the hardwood does not go into the kraft side. Some does slip through but not deliberately.

Mr. Jones: At Fernandina at the present time we are using no hardwood with top or bottom.

Mr. Goodwin: At Jacksonville at the present time we are averaging 15% of a mixture of hardwood going into the base stock. On individual days we have been up over 20% and have not run into any problem on tests or difficulty on the paper machine.

Mr. Rice: The question is asked by Bob Faller of Gulf States Paper Co. what is the lowest and the highest basis weight sheet made from high yield? Do you drop off yield as you drop basis weight? I believe that is sort of a general trend. I know at Red Rock and I think Bathurst when they got up around 90 lb. liner or 69 lb. the yield is the highest. When you got down to 33 and 26 lb. you tend to soften the stock up a little bit to get strength development and the same trend is being followed in Jacksonville to a degree. We still haven't explored all the high yields but we seem to be able to handle 90 lb., 69 lb. up pretty high. Isn't that right, Lloyd?

Mr. Goodwin: We have no problem in that respect.

Mr. Rice: Sometime ago a question came in on sulfidity and I believe I by-passed it. The question was how is sulfidity maintained by the various mills? Is it on purpose or do they do something to keep it up or down? John.

Mr. Hart: In Red Rock they don't add elemental sulfur. Sulfidity is maintained by salt cake.

Mr. Ellen: We are using sulfur to some extent. During the week, of course, we run our tall oil plant 5 days a week. Normally during the week we don't use any sulfur makeup. Possibly over the week end we do add some. We maintain a sulfidity of around 25%. Frankly, I think we could possibly get a little lower than that around in the neighborhood of 23 but it has a psychological effect on the papermakers and as long as they like to see it at 25, we have no particular objections. We add our sulfur bagged directly into our recovery furnaces. We feel that it is probably, although it is a little more expensive possibly than some other product, still it is the less troublesome to us and we feel by the time the bag burns away, the sulfur is molten and we get less loss also. We add it directly to the recovery furnace, just toss the bag into the door.

Mr. Jones: We use a small amount of sulfur. Our sulfidity runs in the order of 21 to 25%. We have to use a little sulfur for sulfidity control. We do it by dissolving sulfur in white liquor and pump it directly into the salt cake mixing tank ahead of the recovery and we find that we get no odor at all from it and very little if any loss and it works out very well with us.

Mr. Goodwin: We use no sulfur makeup. The sulfidity ranges from 20 to 25% and it more or less seeks its own level as we have to more or less add salt cake to keep our liquor volume.

Mr. Rice: Question is asked by Hans Tonnag. How much can the yield be increased without interfering with paper or board strength and specifications? That to some extent is why this panel is up here. We don't know. That all depends on your refiner, your consistency of refiners, the whole picture on high yield comes into that question.

Mr. Hart: On that question from the quality of the fiber from the work that was done at the Institute, it would seem

that on that slide that I showed a little while ago it would seem that you could go up to a little between 60 and 65% in yield. You may lower the strength somewhat, but without intrinsically lowering it to a great amount. Sixty five per cent seems to be a magic figure below which you can develop pretty good strength in high yield pulp, be it kraft or sulfide. Beyond that the strength drops off very rapidly. I am speaking from laboratory cooks now.

Mr. Rice: We have gone over the tentative agenda we had. I didn't think we could cover as much. I know it has not been in too much detail. Now I would like to open the meeting to people on the floor.

Raymond Aldrich (St. Regis): I would just like to make a couple of statements about the Kappa number, chlorine number, and K-number, which maybe some of you are not familiar. It happens that I was on the Chemical Methods Committee when all of this work came up and worked with revision of the chlorine number and the writing of the Kappa number. It happens that the Pulp and Paper Research Institute of Canada has done extensive work in trying to determine some method of controlling higher yield cooks than was available with the present T-214. They worked at this from several angles and as a result of their basic work, both the Kappa number and the chlorine number revisions came into existence. We have found from the work there essentially data from the Pulp and Paper Research Institute of Canada which is available in the trade journals that the present K-number, because of its primary limitation of 5 min. reaction time, it starts to be less sensitive up to the equivalent of 40 to 50 K-number even if you use modification as most people do and the 75 ml. K-number is slightly higher. The Kappa number of permanganate oxidation number using 10 min. reaction when the concentration is in that area, you get up to around 70 to 72% yield without losing its sensitivity. That varies a little bit depending on the cook. It is essentially a straight line linear relation between lignin and the permanganate consumption. That is, provided you have a 10 min. reaction time and the concentrations. The chlorine number is going up to about a 75 to 78% yield with proper care. The Chemical Methods Committee therefore feels and it is so that the new Kappa number is probably the most sensitive and easily run, and recommends it for anything up to about 70% yield. If you go up above that and very few people do, the chlorine number will be necessary. The committee at present feels that we should bury the present T-214 with appropriate ceremony for a method that has lived a long and useful life in a few years and put it in our archives. Pulp and Paper Research Institute of Canada personnel who were instrumental in developing and modernizing both of them are very strong in doing the same with the chlorine number. However, the rest of the committee turned them down once and probably will again.

Mr. Rice: Are there any other questions on this story of high yield?

Mr. Anthony Pesch (International Paper Co.): The matter of effect on per cent yield of sodium sulfite has been discussed today and other times. To some people some of the data is a little bit confusing. I mean they are about to jump to wrong conclusions. The only reason why wood is cooked is to reduce the yield. If we didn't want to reduce the yield, we would make ground wood pulp. As soon as we use kind of delignifying agent and cook the wood, we reduce the yield. Now the different delignifying agents, the different chemicals in the cooking liquor, of course, are going to influence the loss in yield that we want to avoid but just because sodium sulfite decreases yield doesn't mean that high sulfidity is not gone.

E. T. Gues (B. C. Forest Products): That question about the sulfur addition was very interesting to us and I just wonder if we could follow through a little bit more, particularly that method of putting the sulfur into the white liquor and pumping it in and I would like to enlarge on my question a little bit. If anybody else has had this experience; we have done some work determining the total sulfur loss as such and it is rather interesting. We keep coming out with pretty much the same figure where the salt cake make-up goes down the sulfur usage goes up proportionately because the sulfur loss on a given operation appears to be very difficult to control. In other words your losses up the stack are more or less constant unless you do something drastic about them. This matter of having to put in sulfur becomes quite apparent as you improve the rest of your system. So I would just like to ask what quantities are involved in this white liquor method and perhaps on the bags.

Mr. Ellen: As far as we are concerned right now, we are running overall on sulfur, of course, our salt cake loss runs in the neighborhood of 95 lb. per ton of board. Actually, we are getting back from our tall oil operation in the neighborhood of 20 to 25 lb. of salt cake per ton of board so the 95 lb. may sound a little low to some of you but still and all, when you add the amount we get back from our tall oil plant, it is in the neighborhood of 115 to 120 lb. Our sulfur addition based on a per ton of board is running in the neighborhood of 4 to 4½ lb. As far as our addition is concerned with the bags we simply put it in 100 lb. bags and we just have a shute directly into the furnace and we just open the door. We only add a bag about every hour or every other hour and there is no question about it, we can tell immediately as far as the sulfidity is concerned in the green liquor when you start adding it. We just open the door on the furnace, put a bag in the shute and shoot it in. Actually what happens, the bag itself and the weight of it, of course, you are carrying a fuel bed in the bottom of your recovery furnace and the thing plunges to the bottom and is covered up so that that is the reason we feel that by the time the bag itself is burned away, you more or less have a molten lump of sulfur in the bottom of your bed and we just feel that we get less loss that way than we would by trying to spray it in by any other way. Of course, Franklin is doing it differently. As far as his losses are concerned, I just don't know what the situation would be.

Mr. Jones: We use in the order of 3 to 5 lb. when we are using sulfur and we use about 12 g.p.m. white liquor and feed this sulfur into a small tank with a little feeder. Of course, we don't know exactly what our losses are, probably in the same order as any other losses up your stack would be. Our salt cake makeup normally is in the range of 110 lb. per ton and we think it has some advantages; however, it is a very simple thing to drop a bag of sulfur in a recovery boiler and get it over with. I could not say how they would compare in losses. I don't know whether that would be any different or not.

A comment from the floor: In kicking this sulfidity around, as a matter of interest, we don't make high yield, we make light weights and we have tried sulfur as liquid in the furnace, as bags in the furnace, and the green liquor and the white liquor directly to the digesters and as lump sulfur it amounts to 100 lb. per ton of finished paper directly in the digester. Now anyone of the addition points gives you the same effect as far as the sulfate cook is concerned, but if you are going to analyze by conventional methods for sulfidity, then you are going to kid yourself as to the amount of active sulfur you have available.

Mr. Borlew: What you really get when you dissolve sulfur in white liquor is polysulfite and you have to analyze it according to special methods and separate monosulfite and polysulfite. Now there should be, of course, no special losses in the recovery because as soon as you cook with polysulfite it is claimed that there is no polysulfite layer as discernible in black liquor though there is some literature on it which claims there would be some polysulfite in the black liquor. That would have to be decided. We don't know but as long as your black liquor has the same qualities of composition, I don't see where there would be any later losses or difference

in losses between methods of adding sulfur whether you add it in the white liquor or whether you add it in the recovery.

Mr. Hart: The amount of polysulfite that you have in your cooking liquor will effect your corrosion, or will it not? I seem to recall some work that we did at the Institute some years ago in which we tried to have sulfidity made up entirely from polysulfite and we were just doing it in small bombs but from the color of the bombs a lot of metal went into solution.

Remark from the floor: Some mills and sulfur intentionally because they feel it cuts down the corrosion.

Mr. Hart: It depends upon where you add it though, doesn't it?

George Hanson (Weyerhaeuser Kraft): I would like to know why these people don't oxidize their black liquor and eliminate the need of adding sulfur.

Mr. Rice: We will ask Tex Collins that question. There are people that do it. I think Bathurst does it. I don't know how many others. Someone says about 25 are doing it.

Bob Guide (Longview Fiber): I would just like to add that we do have an oxidizer and we still have to add something like 10,000 lb. of elemental sulfur per day.

Mr. Rice: Any further questions on that subject?

Mr. Guide: We add our elemental sulfur in bag form directly in our furnace and we have found that we can only retain something like 30% of that sulfur in the green liquor. Seventy per cent actually goes out the stack on the first pass.

Another comment from the floor: I imagine that everybody is familiar with the fact that the more alkaline the black liquor is as it gets to the furnace, the more that sulfur will tend to be bound because sulfur is an acid-forming material and soda is an alkali. I think everybody has to appreciate that one of the things that effect sulfur recovery is the amount of active alkali, particularly caustic soda, left in the black liquor at the point where it gets to the furnace or gets to the cascade evaporators or whatever it happens to be. I believe that is an important point. Anybody disagree with that?

Mr. Gues: I would like to raise that question again about active alkali in black liquor. That is another thing we have been delving into a bit. I would like to know what various people try to carry. I guess on this semichemical or this high yield you must have the problem of low active alkali in the black liquor which probably enlarges stack losses. I wonder if you could enlarge upon that subject of active alkali carryover a little bit.

Mr. Goodwin: We attempt to maintain 16 to 18% residual activity in the black liquor.

Mr. Jones: We don't make any particular effort to maintain it as such. We worry about salt cake losses, makeup, etc., and try to hold those in line. I don't know of any problems that we could directly attribute to active alkali.

Mr. Ellen: We are carrying in the neighborhood of 20–22% normally without too much trouble. Actually, we do maintain it better than 18%. If it starts to get up around less than 18%, we do something about it. Of course, we have not had to do something about it in quite a few years, but still we watch it like a hawk and we run it every day continuously.

Mr. Borlew: That boils down to the question of Tony Pesch. Activity is in that case sodium sulfide. We have to find a rapid method. I confess my own method is not about to be used as a control method. To find out what part of it is sodium hydroxide and what part is sodium sulfide, say within half an hour but then you have to go to the trouble and determine the NaOH + the Na_2S and then deduct Na_2S. Now if you want to sacrifice say two hours or four, you may be able to get more or less an intelligent answer. It amounts to probably that at 10% in normal kraft run, 10% of your active alkali as sodium hydroxide and the rest is sodium sulfide. The best thing is to measure the pH of your black liquor and that gives you an indication. If the pH is high you are about to have more sodium hydroxide than sodium sulfide.

Mr. Pesch: In that general connection this has a very direct bearing on this whole matter. How long is it practical to cook high yield pulp, I mean at the maximum temperature? Can you cook 4 or 5 hr. or do you just then have so much trouble at the evaporators and in the recovery room that it is not practical?

Mr. Ellen: Before we ever got into this thing we would make a lot of tests and a lot of cooks on various times and temperatures and alkali content and what not and the various combinations. Actually, I could see no particular reason for wanting to go that long in the first place because if you were trying to make production it would be out of this world on digester capacity. In fact, the quicker we can turn them over and still get wheat we are looking for, the better off we feel we are. I think there is a happy medium in there that you have to be somewhere along the line between the three.

Mr. Hart: Doesn't it depend upon your time to temperature which has to be long enough to get penetration? At Red Rock they are using an average of around 69 to 70 min. to get temperature and about 28 min. at. They are pushing the digesters a bit too much they feel. They would like to go a little bit longer to temperature. The pressure is 90 lb.

Mr. Ellen: I think possibly there is a question in a lot of people's minds as to just how much trouble you want to go to to get penetration. We feel as far as we are personally concerned, we want to go to fairly great lengths because before we even went to high yield we used to have a whole of a lot of trouble with uncooked wood in our sheet. There is no question about it. We got these rejects and we refined them and put them right back into our base sheet. We don't try recooking them and we had these slivers continually show up in it. So when we went to high yield that was one of the main things we tried to avoid, that of trying to get a penetration on the chips sufficiently so that when we would refine them and break them down, the bundles at least we would not have this white fiber. Actually, we feel we have accomplished this purpose because we don't find them any more. The chips we do get are soft enough or pliable enough that you can bend them with the hand and actually shred them unless you get a pine knot and, of course, nothing is going to shred that except refiner of some sort.

Mr. Borlew: I am sorry the word penetration came up again in alkaline pulping. Our sulfite companions probably think that we do have a problem like they have. The penetration of sodium hydroxide is apparently instantaneous for 5 min. but not more. It is the sulfide of course which is a little bit retarded and it has been retarded about five times according to other sources I happen to know of. In view of the fact that sodium hydroxide penetrates the fiber that is really why the acid solution has to go from top to bottom. I don't think it is a question of penetration that is so important as the strength of the caustic in your white liquor. It might have been that you used either too little active alkali or within that active alkali the caustic strength was not sufficient. I think that penetration problem is—of course, it depends on the chip size too, the chip length, and width and all that but let's in that case gather more data before we talk about whether or not penetration is really an important factor or the time of penetration. Because we did hear here that some up-to-temperature times were relatively short. I think some very interesting data in that respect came out the other day in our first paper when the Institute presented that paper on different little digester models. Penetration was apparently abolished.

Mr. Hart: I think you have to take into account though that penetration may be a misnomer but it is the practical application of wetting commercial chips. The alkali and sulfide where it will go in the correct time and that is still a problem and is lumped under I guess what you might call penetration, but if you come up to take a commercial chip without any pretreatment in a digester and put your alkali

in there and come up to temperature too fast, you will get white centers.

DR. HENDERSON: John, May I expand on that? I think you are quite right. Under certain circumstances you can get this. If the liquor is too hot and you have a limited amount of it, you consume it in the outer parts of the fiber and when it gets to the inner part there is just nothing left to react but at the same time if you have enough of it there so that it won't be consuming you can bring them up just as fast as you want to in 2 min. or something.

MR. HART: On the other hand, if you have that strength of alkali and ordinary commercial chips the strength may be a detriment to the quality of pulp in the outside of the chip.

DR. HENDERSON: It depends on the wood species. Hardwood will go much better than soft wood.

MR. HART: Yes, but if you take soft wood, Douglas-fir, spruce or something and use commercial chips and have alkali that is strong enough to give you penetration in two minutes then you won't get as good a quality of pulp from it.

DR. HENDERSON: That is right. I will go along with that.

MR. RICE: Gentlemen, are there any other questions from the floor on any aspect of this discussion that may have appeared of interest to you and the description of it wasn't thorough enough? Are there any questions that the panel would like to ask people on the floor? Well, gentlemen, we don't want to bat this to death the first time we have had a session like this on high yield. There is one thing that gratifies me very much. The room is almost as full after the break as it was before which gives me the feeling that some interest has been created. I want to thank you very much for your attendance and hope that some information has come out that will set some wheels turning and especially maybe some people of TAPPI will try to pin down the chlorine, Kappa number and permanganate number on a research project of some type and give us something substantial to go on. I now declare the session over.

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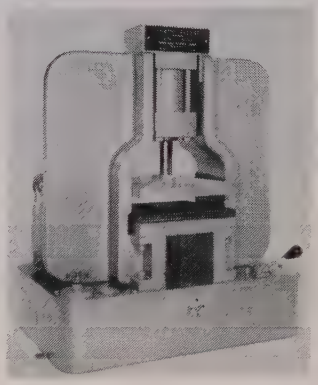

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LOCAL SECTION ACTIVITIES

Meeting Calendar

March, 1961

2 Lake Erie Section, Cleveland, Ohio. "Paper and Paper Technology and Paper—Its Future as a Profession."

3 Central District, Empire State Section, University Club, Syracuse, N. Y. "New Developments in Corrugated Boxes," by P. Palmaccio, Mead Corp.

7 Berkshire District, New England Section, Wendell-Sherwood Hotel, Pittsfield, Mass.

7 Chicago Section, Chicago Bar Association, 29 S. LaSalle St., Chicago, Ill., "The Development of plastics as a Packaging Medium"—Plastic Films: R. C. Krueger, DuPont; Extrusion Coatings: A. E. Irvine, Union Carbide; Solvent, Water Based, & Hot Melt Coatings; W. C. Ashley, Pyroxylin; Molded Containers: R. V. Jones, Phillips; Panel Chairman; Mike Hecht, Chicago Carton Co.

9 Northern District, Empire State Section, Hotel Woodruff, Watertown, N. Y.

10 Virginia-Carolina Section, John Marshall Hotel, Richmond, Va., Dinner Meeting.

13 Bay District, New England Section, Armand's Beacon Terrace, Framingham, Mass.

14 Metropolitan District, Empire State Section, 465 Lexington Ave., New York, N. Y. "The Paper Industry in Europe," by A. W. Wilson, Editor, *Pulp and Paper*.

14 Lake State Section, Kaukauna Elks Club, Kaukauna, Wis., Utilization of Hardwood Pulps in the Lake States Area.

14 Ohio Section, University Center, Miami University, Oxford, Ohio. "Appearance Properties of Paper," by Richard Hunter, Hunter Associates Laboratory.

16 Kalamazoo Valley Section, Inman's Restaurant, Galesburg, Mich. Joint Meeting PIMA-TAPPI-Craftsmen on Graphic Arts.

17–18 Delaware Valley Section, Benjamin Franklin Hotel, Philadelphia, Pa. Philadelphia Graphic Arts Conference.

21 Golden Gate Section, Crown Zellerbach Bldg., San Francisco, Calif.

21 Pacific Section, Longview, Wash. Shibley Award Meeting.

21 Indiana District, Ohio Section, Marott Hotel, Indianapolis, Ind. Education Committee Meeting, "Who We Are and What We Do" (Indiana High School Science Teachers as guests), Dr. Alfred H. Nadelman, Western Michigan University.

24–25 Southeastern Section, Bon Air Hotel, Augusta, Ga. Tour of Continental Can Co. paper mill.

April, 1961

4 Chicago Section, Chicago Bar Association, 29 S. LaSalle St., Chicago, Ill. F.D.A. (Tentative, will hold if warranted).

6 Lake Erie Section, Cleveland, Ohio. "The Advantages and Disadvantages of Letterpress and Flexography."

6 Kalamazoo Valley Section, Inman's Restaurant, Galesburg, Mich. Visit to Michigan Carton Co.

7 Central District, Empire State Section, University Club, Syracuse, N. Y. Senior Night-Junior Awards.

7 Gulf Coast Section, Pine Bluff, Ark.

10 Pioneer Valley District, New England Section, Storrowton Tavern, West Springfield, Mass. Management night.

11 Metropolitan District, Empire State Section, 465 Lexington Ave., New York, N. Y. "The Reused Fiber."

11 Lake States Section, Mill visit—Neenah Paper Mill of Kimberly-Clark Corp. Dinner at Menasha Elks Club. Theme: Strength Evaluation of Pulps, also C. J. West Award.

13 Ohio Section, Tour National Cash Register Co. at Dayton, Ohio.

13 Northern District, Empire State Section, Hotel Woodruff, Watertown, N. Y. Joint meeting with Beaver Falls Chapter, A.I.C. "The Planning of a Technical Center," by K. A. Arnold, St. Regis Paper Co.

18 Indiana District of the Ohio Section. Plant Tour, Container Corp. of America corrugating medium mill, Carthage, Ind. Dinner at Durbin Hotel Rushville, Ind. "Machinery of Paper—Part III–Beater Room Equipment," N. S. Balfour, Beveridge Paper Co.

20 St. Louis Section, LeChateau Restaurant, 10405 Clayton Road, St. Louis, Mo., "Paper and Ink Relationships," John C. Brazrell, Champion Paper & Fibre, Co.

27 Delaware Valley Section, Engineers Club, Philadelphia, Pa. Program on wet end retention by The Institute of Paper Chemistry.

May, 1961

2 Chicago Section, Chicago Bar Association 29 S. LaSalle St., Chicago, Ill. "Structural Design: Corrugated & Folding Cartons."

4–5 Pacific Section, Harrison Hot Springs, Canada.

5 Central District, Empire State Section, Syracuse, N. Y. Ladies Night.

9 Golden Gate Section, Claremont Hotel, Berkeley, Calif.

11 Northern District, Empire State Section, Hotel Woodruff, Watertown. Annual Ladies' Night.

11 Ohio Section, Hartwell Recreation Hall, Cincinnatti, Ohio. Ladies' night.

11 Lake States Section, Green Bay Wis., Hotel Northland, Dinner meeting during National Symposium on Pulp & Paper Instrumentation. Theme: Instrumentation and Its Future.

16 Indiana District, Ohio Section, Marott Hotel, Indianapolis, Ind. "FDA Regulations—Current Status."

19 Metropolitan District, Empire State Section, Tavern on the Green, New York, N. Y. Ladies' Night.

19–20 Southeastern Section, General Oglethorpe Hotel, Savannah, Ga.

25 Delaware Valley Section, Engineers Club, Philadelphia, Pa. E. J. Albert Award.

25 Kalamazoo Valley Section, Gull Harbor Inn, Gull Lake, Joint PIMA-TAPPI Recognition Night.

25 Delaware Valley Section, Philadelphia, Pa.
26–27 Gulf Coast Section, New Orleans, La.
Virginia-Carolina Section, Dinner Meeting and Mill Tour.

June, 1961

8–10 Empire State Section, Whiteface Inn, Whiteface, N. Y.
8–10 New England Section and Main-New Hampshire Section. Joint Meeting. Wentworth-by-the Sea, Portsmouth, N. H.
10 Lake Erie Section, Cleveland, Ohio. Annual Dinner Dance, Greenbriar Restaurant, Parma Heights, Ohio.
20 Kalamazoo Valley Section Gull Lake Country Club, Gull Lake. Joint TAPPI-PIMA fun day.
20 Indiana District, Ohio Section, Anderson Country Club, Anderson Ind. Fourth Annual Golf Outing.

June, 1962

1–2 New England Section, Chatham Bars Inn, Chatham, Mass.
7–9 Empire State Section, Whiteface Inn, Whiteface, N. Y.

June, 1963,

6–8 Empire State Section, Whiteface Inn, Whiteface, N. Y.

June, 1964

11–13 Empire State Section, Whiteface Inn, Whiteface, N. Y.

September, 1961

21 St. Louis Section "Paper Mill Visit."

November, 1961

30 St. Louis Section.

Pacific

The first meeting of Pacific Section TAPPI for the 1960–61 year was held in Salem, Ore., November 16, at the Marion Motor Hotel. The meeting theme was "Modernization" and was moderated by Hans Brune of Columbia River Paper Co., Oregon Pulp & Paper Div., Salem, Ore.

The program starting at 2:00 p.m. saw three speakers presenting their technical papers as follows:

Messers. Hammack, Brune, Esselman, Davis, speakers at the Pacific Section Meeting

G. R. Cranor, General Superintendent, Columbia River Paper Co., Salem, Ore.; Felix Hammack, Western Kraft Corp., Albany, Ore.; Karl W. Heinlein, Res. Mgr., Columbia River Paper Co., Salem, Ore; Roy Webster, After dinner Speaker, Res. Mgr., Lybrand, Ross Bros., and Montgomery, Portland, Ore.; P. T. Dickie, Chairman, Pacific Section TAPPI (Crown Zellerbach Corp., West Linn, Ore.); Hans Brune, Moderator (Columbia River Paper Co., Salem, Ore.)

"Two Changes in Sulfite Mill Acid Plant Operations," by Donald R. Davis, Publishers' Paper Co., Oregon City, Ore.
"New Applications in Kraft Pulping," by J. B. Esselman, Georgia-Pacific Paper Co., Toledo, Ore.
"How Flash Drying Affected Lime Mud Reburning and Recausticizing Operations at Western Kraft's Albany Mill," by Felix M. Hammack, Western Kraft Corp., Albany, Ore.

Following the technical meeting, a large number of those in attendance visiting the Columbia River Paper Co.'s mill in Salem and a smaller group motored 20 miles to the south to visit Western Kraft's mill in Albany.

A social hour at 6:00 p.m. followed by dinner at 7:00 p.m.,

Nov. 16, 1960, Pacific Section Meeting, Salem, Ore. Roderick Perkins, Columbia River Paper Co., Salem, Ore.; G. R. Cranor, Columbia River Paper Co., Salem, Ore.; Felix Hammack, Western Kraft Corp., Albany, Ore.; Karl Heinlein, Columbia River Paper Co., Salem, Ore.; Roy Webster, Lybrand, Ross Bros., and Montgomery, Portland, Ore.; P. T. Dickie, Crown Zellerbach Corp., West Linn, Ore.; Hans Brune, Columbia River Paper Co., Salem, Ore.; Curtis Walseth, Weyerhaeuser Co., Cosmopolis, Wash.; Norval Magnusson, Puget Sound Pulp & Timber Co., Bellingham, Wash.; R. Burke Morden, Morden Machines Co., Portland, Ore.

was highlighted by our afterdinner speaker, Roy Webster, resident manager of Lybrand, Ross Bros., and Montgomery, Portland, Ore., whose topic was "Data Processing in the Paper Industry."

ROBERT SMYTHE, *Secretary-Treasurer*

Two Changes in Sulfite Mill Acid Plant Operations

Donald R. Davis

PUBLISHERS' PAPER CO. is involved in a continuing program to streamline and increase the capacity of the acid plant in its sulfite mill. This program has included the installation of a liquid sulfur system and the substitution of burner gas for accumulator gas in the production of the sulfurous acid needed for our zinc hydrosulfite manufacture.

Sulfur is delivered in leased tank cars. They serve as our principal sulfur storage as there is no room for the construction of a sulfur sump. Two cars are always in position on the track in the acid plant. The sulfur is melted by steaming for 24 hr. in advance of unloading. Steaming, at a reduced rate, is continued during the $3^1/_2$ days needed to unload the car. Air pressure is introduced into the top of the car at 25 p.s.i.g. and the sulfur is pushed through steam traced lines into three small storage tanks. These tanks, which have a 16 hr. capacity were previously used to melt solid sulfur. From these tanks the sulfur flows by gravity to the sulfur burners. Air pressure in the tank cars is regulated with a pressure reducer. Steam to the sulfur cars and storage tanks is regulated by the operator.

The change-over was accomplished without any interruption to production and at small cost since a large part of the equipment used previously was utilized. The whole operation is essentially trouble free. No tank car has been overheated to the point where the sulfur would not flow. Seals have, however, been blown out of a few tank cars due to an excessive amount of air added. In one case this resulted in a fire. Occasionally we have run out of liquid sulfur due to delayed delivery or a bad order car. In such cases we easily revert to solid sulfur as all the equipment needed to handle it is still in place.

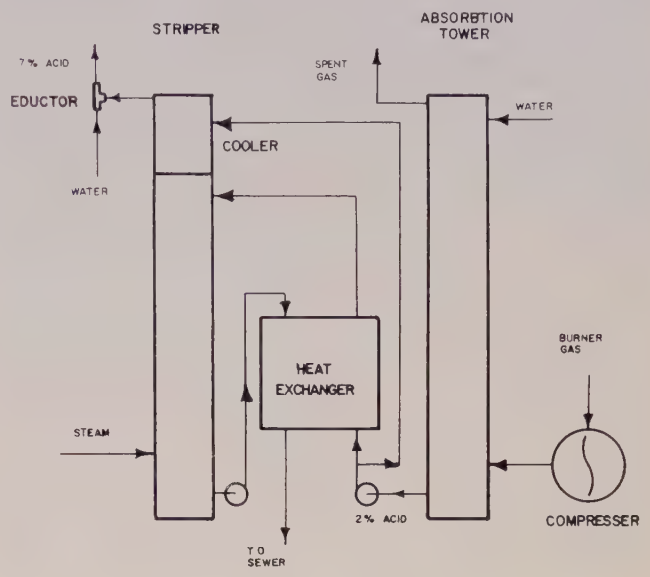
On the balance, when compared with the handling, the dust, and the occasional explosion and fire involved with the solid sulfur operation, the liquid sulfur system has proved very satisfactory.

Our groundwood mill bleaches with zinc hydrosulfite, which it makes using a 6 to 7% SO_2 solution obtained from the sulfite acid plant. The sulfur dioxide for this solution was obtained from accumulator overgas which is approximately 90% SO_2. After reducing the pressure to 15 p.s.i.g. the overgas was contacted with water, countercurrently, in an absorption tower. This tower was 12 in. diam. and had a 12 ft. section packed with 1-in. Raschig rings. Spent overgas was vented to the third Jennsen tower. Maximum production under good conditions was 4 g.p.m. of 6% acid.

For the manufacture of zinc hydrosulfite the groundwood mill prefers an acid containing above 5.5% SO_2. Lower concentrations reduce the capacity of the zinc hydrosulfite reactor. When the acid from the sulfite mill is below strength or not available, the groundwood mill uses purchased liquid sulfur dioxide to produce sulfurous acid of the proper strength. The liquid sulfur dioxide is introduced into water through a mixing valve. It was found that more zinc was used per pound of zinc hydrosulfite produced when using purchased liquid sulfur dioxide than when using sulfur dioxide solution supplied by the sulfite mill. This lower efficiency coupled with the cost involved in buying liquid sulfur dioxide makes its use a very expensive business.

DONALD R. DAVIS, Publishers' Paper Co., Oregon City, Ore.

In the first years of zinc hydrosulfite manufacture, liquid sulfur dioxide was only used when the sulfite mill was down. In the summer of 1958, liquid sulfur dioxide was being used over 40% of the time. The groundwood mill had increased production and was being supplied with wood that was producing a duller pulp. More zinc hydrosulfite was required to keep our groundwood brightness constant. At the same



time the sulfite mill had increased production to the point that they were being held back by lack of cooking acid. Warm water conditions in the summer aggravated conditions. Accumulator overgas was not released for periods as long as 24 hr. so that the cooking acid strength could be kept up. When overgas was released it was in small quantities. As a result, small amounts of weak sulfurous acid were produced. In the winter the situation was better, but liquid sulfur dioxide was being used at the rate of 2 to 3 thousand pounds per week.

The source of sulfur dioxide for making sulfurous acid had to be changed. The only other in plant source of sulfur dioxide was burner gas, which contains 16% SO_2. A single-stage absorption of sulfur dioxide from burner gas at high pressure was rejected for two reasons. First, was the cost of a compressor and high pressure absorption tower. Second, was that a pressure tower which was being installed to fortify the cooking acid would be using compressed burner gas in the 4 to 8 p.s.i.g. range. One compressor could feed both processes. This arrangement was installed. Burner gas is compressed to a pressure that varies between 4 and 8 p.s.i.g., depending on the needs of the cooking acid. Part of the compressed gas is piped to the new sulfur dioxide absorption system. The first stage of this system is absorption of sulfur dioxide from the burner gas to produce a 2.0% solution of sulfur dioxide. Absorption, at an average rate of 15 g.p.m., takes place in a tower that is 20 in. in diam. and is packed with 20 ft. of $1^1/_2$ in. intalox saddles. The tower is constructed of 316 stainless. To minimize corrosion from traces of sulfur trioxide in the burner gas, the stainless was specified to contain 2.75% molybdenum and a maximum of 0.03% carbon. Spent gas is exhausted back to the burner gas line at a point just before the first Jennsen tower. The lines handling gas are fiberglass impregnated with polyester resin. The weak sulfur dioxide solution is pumped to a steam stripper. On the way it passes through a heat exchanger where it is heated by the stripped acid. The stripper was made from the absorption tower used in the old setup. A steam outlet was put in just below the packing support. Packing was changed to $1^1/_2$-in. intalox saddles. A cooling

section was added at the top to cool the sulfur dioxide that was stripped out. Approximately 3 g.p.m. of weak acid goes directly from the absorption tower to the cooling section, where it contacts and cools the gaseous sulfur dioxide by means of a series of perforated trays. The sulfur dioxide, now at about 90°F., is fed to an eductor where it is absorbed in water at a concentration averaging 7%. By the time the acid storage tank in the groundwood mill is reached, absorption is complete. Hot water leaves the stripper containing less than 0.06% SO_2. After a trip through the heat exchanger it is sewered. The heat exchanger is of the plate type and takes floor space amounting to less than 3 sq. ft.

Controls are simple. The stripper and absorption tower have level controllers. Pressure in the stripping column controls the steam rate and, in conjunction with the temperature and flow rate of water through the eductor, determines the concentration of sulfur dioxide absorbed in the eductor. Rotometers are on the water feed lines and on the weak acid line to the cooler. Thermometers indicate the temperature of the stripped acid in the bottom of the stripping column and of the gaseous sulfur dioxide just before it enters the eductor. A gage was installed to show the level in the acid storage tank. The acid plant operator sets the water flow rate through the eductor at a rate sufficient to keep the storage tank at a constant height. Stripper pressure is adjusted, as necessary, to keep the strong acid concentration above 6.0%. The weak acid rate should be high enough to supply all the sulfur dioxide that can be absorbed by the eductor. The proper balance of weak acid to strong acid is indicated by the temperature of the stripped weak acid at the bottom of the stripping column. The operater has a chart with a range of correct operating temperatures for the pressure at which the stripper is operating. This operating range is such that the stripper effluent contains from 0.03 to 0.06% SO_2. If more weak acid is needed the temperature goes up and if less is needed the temperature goes down. Flow rate through the cooling section is determined by the temperature of the cooled sulfur dioxide. Minor upsets are caused by changes in water pressure but they usually correct themselves as the changes in water flow rates are roughly in proportion.

In case the compresser is down, sulfur dioxide solution can still be made but at reduced capacity. Burner gas is obtained at the pressure side of the acid plant fan and the exhausted gas goes to the third Jennsen tower. Loss of capacity results from lack of gas velocity through the absorption section rather than from the reduced pressure.

The new sulfur dioxide absorption system has operated satisfactorily for a year and a half. The previous method of production could only produce about 4 g.p.m. of 6% acid under the most favorable conditions. The present system produces 5 g.p.m. of 6% acid under the most adverse summer conditions, i.e., 75°F. water. We did, however, have to supplement with about 2000 lb. of liquid sulfur dioxide this summer while we were pulling down an old groundwood pile. Maximum capacity during the winter is 6.5 g.p.m. of 8% acid. Summer capacity could be increased with the use of cold well water or with larger pumps and a larger eductor; winter capacity could be increased with a larger eductor. Corrosion has been small. Stainless valves on the compressed gas line do not seal and a weld in the older part of the stripping column developed a leak. The plate-type heat exchanger has given no trouble at all. Concerning the heat exchanger, it is interesting to note that the setting on the steam valve is the same regardless of production rate. Little attention other than a passing glance has been required from the operaters—many shifts go by with no hand adjustments at all being made.

Presented at the meeting of the Pacific Section of TAPPI, held in Salem, Ore., Nov. 16, 1960.

How Flash Drying Affected Lime Mud Reburning and Recausticizing Operations at Western Kraft's Albany Mill

Felix M. Hammack

The theme of today's program, I'm told, is that of modernization of pulp and paper processes and practices. In keeping with this general theme, the title of my paper suggests that the operation of our lime reburning and recausticizing equipment may have been revolutionized rather than modernized by the addition of a flash drying system, but such has not really been our experience. I must admit, however, on behalf of my colleagues, that there have been times when our operating people have felt that they could handle a revolution with more success than they were enjoying with the operation of the kiln and flash drying system. Especially after one of those hectic days when the kiln gun spent more time in the mount than it did on the wall.

Though some revolutionary ideas have been advanced in recent years concerning this often neglected area of a kraft pulp mill, our experience with a flash drier can be considered only as one step in the direction of modernizing kraft mill operations and design. Most of us, I'm sure, can see many areas in pulp and paper manufacture where design and operation changes should now be made; even to the extent of approaching much of what we now take for granted with entirely new concepts. In the future, I am confident that many of these changes will be made—and profitably so—but, unfortunately, too few are willing to be first in such an endeavor. Maybe if we could do away with this need for someone to be first, there would be more of the would-be seconds constructively doing something about these problems of modernization.

My real objective today is not to philosophize in a general way about what I think the future holds, but, rather, my objective is to give to you some specific design, operating, and maintenance information about a rather limited but significant facet of our operations in Albany. I am, therefore, here not as a specialist in design, operation, or maintenance of flash drying systems, but as a representative of Western Kraft's Albany mill who has gathered operating, design, and maintenance information from our people and from the equipment manufacturer and who will attempt to give this to you in the few minutes alloted for this purpose.

First of all, our Albany mill began operations about five years ago in September of 1955, and at that time it had a design capacity of approximately 120 tons per day of kraft pulp and linerboard made exclusively from Douglas-fir waste chips. As most of you no doubt know, a lime mud reburning plant is a necessary part of a kraft pulp mill chemical reconstitution system and it takes lime mud containing the calcium carbonate precipitate formed through the double decomposition reaction between slaked lime, $Ca(OH)_2$, and the sodium carbonate, Na_2CO_3, contained in the green liquor from the chemical recovery furnaces and drives off both the moisture and the carbon dioxide (CO_2) to produce quick lime, CaO, for use again in the reaction with more sodium carbonate. A substantial portion of the sodium carbonate, approximately 80 to 85%, is thereby changed to the more active sodium hydroxide, which with the other constituents of the liquid phase of the liquor, namely sodium sulfide and unreacted sodium carbonate, is sent to the digesters for cooking fresh chips again.

To process the lime mud in our mill initially, a used kiln 7 ft. diam. and 120 ft. long manufactured by Vulcan Iron Works was purchased and installed. The rated capacity of this kiln is approximately 35 tons per day of quick lime expressed as 100% active calcium oxide, CaO, and based on a moisture content of approximately 45% in the mud fed to the kiln. (Incidentally, the average composition of this mud is

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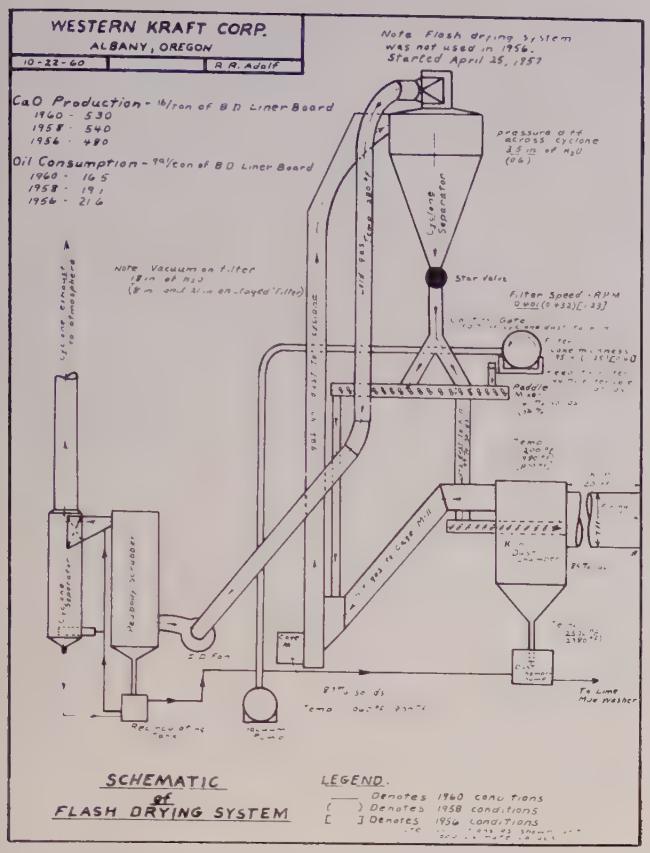

such that the reburned product from our kiln consists of approximately 83 to 87% CaO, 5 to 10% other calcium containing compounds expressed as CaO, 0.5 to 1.0% oxides of iron expressed as Fe_2O_3, 1.0% aluminum compounds expressed as Al_2O_3, and 3 to 8% sodium compounds expressed as Na_2O.)

Most rotary kilns of this type have a chain section in the wet end comprising numerous loops suspended from lugs attached to the inner shell at the point of entrance of the wet filter cake. The purpose of these chains presumably is to increase the surface area of contact between the hot flue gases and the wet feed so that faster drying is accomplished. Also, there are some who apparently feel that the chains, through the influence of the rotating action of the kiln, assist in the formation of lime mud pebbles of uniform particle size which provide for a more uniform product particle size at the discharge end of the kiln. This uniformity, therefore, presumably minimizes fluctuations in the recausticizing reactions between the lime and the liquor which follow, and though this in itself has no direct bearing on the specific subject at hand, which is the flash drier, you will see the connection later as I show you samples of our product which have passed through the flash drying system.

We operated our kiln from September, 1955, for about six months with the chains in place. As they began to wear away, however, rather than replacing or maintaining them, we simply eliminated them and without any apparent ill effects. We continued to operate in this manner thus producing enough reburned lime to meet our demands while producing an average of 120 to 125 tons of pulp and linerboard per day. This required an average of about 29 to 30 tons of reburned CaO per day. In the fall of 1956, having operated successfully for a year, plans were already underway to expand our pulp and linerboard production. Based on anticipated future needs, it was decided to expand our lime mud reburning capacity from 35 tons to 70 tons per day of CaO, so as to meet future demands of the pulping operation.

In planning this expansion, probably the first thought that came to the minds of our Engineering and Production Departments was to simply purchase another kiln of the same size and capacity. (In spite of our success with the flash drying system, I have been unable to learn who was responsible for suggesting the approach that was taken toward this expansion of our lime mud reburning capacity. Perhaps they were too busy to remember how it all got started.) I have found correspondence in our files, however, between the Raymond Division of Combustion Engineering and Western Kraft personnel wherein the Raymond Division pointed with pride to several other such installations already completed and operating successfully. These earlier installations were at Camp Manufacturing, now merged with Union Bag; The Chesapeake Corp.; St. Mary's Kraft; and Howard Smith Paper Mills.

While Western Kraft was negotiating with Raymond, it was learned that the Southern Advance Division of Robert Gair, which is now a division of Continental Can, had placed an order for a flash drying unit for their mill in Hodge, La., of the same general size and capacity as was considered necessary for Western Kraft's expansion. Since this time, another unit has been placed in operation at Hodge, La. Thus, Western Kraft was the first on the West Coast to purchase and install such a modification to their lime reburning process, and it may be interesting to note that there are a total of eight units now in operation, two of which were recently installed in Japan.

The sketch of our flash drying system which has been prepared for you, (and I might add that this is intended only as a sketch) shows how we effect the removal of moisture from our lime mud prior to introduction of the feed into the kiln itself. Very simply stated, the hot exit gases from the kiln are brought into intimate contact with a mixture of lime mud filter cake and recycled dust. The suspension of this pulverized mixture in the hot gas stream provides for rapid evaporation of moisture introduced into the system with the filter cake as the particles flow from the cage mill to the cyclone separator where the essentially bone dry dust separates from the main gas stream. The gases are thereby cooled to approximately 280°F. from a present kiln exit temperature of about 1200°F.

From the cyclone separator, approximately half of the dust is conveyed to the kiln as feed with the screw conveyor shown, while the remaining half is recycled to the paddle mixer for use in pulverizing the wet filter cake preparatory to its suspension by the hot kiln exhaust gases in the cage mill. The cooled gases drawn from the top of the cyclone separator by the induced draft fan are forced through both a Peabody scrubber and an after cyclone for removal of remaining dust particles prior to their discharge to the atmosphere saturated with water vapor at an approximate temperature of 160°F. The dust particles which are scrubbed out in the three areas shown return to the system at the lime mud washer as a weak slurry, and this stream then becomes the washing medium for the lime mud underflow from the white liquor clarifiers.

Initially, it was recommended by Raymond that we choose our operating conditions such that the kiln feed would contain 10% moisture to avoid excessive carryover with the kiln exhaust gases from the discharge of the charging screw. This was attempted unsuccessfully several times and abandoned because of caking and plugging of the charging screw at this moisture content. Ever since the first few days of operating, therefore, our flash drying system has been operated in such a manner that the kiln feed contains less than 1% moisture. This change in operating conditions has permitted us to operate continuously without dust carryover problems and, surprisingly enough, the reburned lime product comprises remarkably uniform pebbles averaging between $\frac{1}{4}$ and $\frac{1}{2}$ in. diam. (I might also mention here that not only can *pebbles* be produced, but *balls* of extraordinary size and uniformity can likewise be produced when conditions are favorable. Exactly what those conditions are, we are not certain. However, we have many suspicions—as no doubt

many of you have—but these, perhaps, could be more appropriately aired in another meeting.)

You will note in referring to the sketch that whenever possible representative operating conditions have been given for 1956, which was prior to the installation of the flash drier, for 1958, which was about 18 months after startup of the flash drier, and for 1960. For each of these three years, the month of October was chosen for compiling average data so as to minimize any influence that may have resulted from seasonal changes. I would like to call your attention in particular to the temperature changes that have taken place because of this process change. Because of the higher kiln gas exit temperatures, we have—in essence—made the entire 120 ft. length of the kiln into a radiant zone and have changed the refractory lining accordingly so that the same type of bricks is used throughout.

Though we have a Peabody scrubber in service, it is not used as it was designed to be used. Rather, we have removed sections of the internal baffles and plates so that flow through it is essentially unimpeded; thus, it becomes more of a stilling chamber containing showers for scrubbing.

You will also note that fuel oil consumption is reported in gallons per ton of linerboard produced and though the lime production per ton has progressively gone upwards from 480 to around 530 lb. per ton as CaO, which is an increase of about 10%, the fuel oil consumption has been reduced from 21.6 to 16.5 gal. per ton of linerboard produced, or a reduction of about 23.5%. Similarly, if we were to express performance as pounds of CaO produced per gallon of fuel oil, it would be seen that in 1956, before the flash drier was installed, 22.2 lb. of CaO were produced per gallon, while in 1960, 32.1 lb. of CaO were produced per gallon. This significant increase in thermal efficiency is approximately 45%. All of this change has not been the direct result of having installed a flash drying system, however. Rather, I would suggest that only about 60% of this gain in thermal efficiency could be attributable to flash drying of the wet feed. The remaining apparent thermal efficiency increase was effected through increases in the solids content off the lime mud filter made possible through changes in the filter itself and in the vacuum system attached to it.

Perhaps you are wondering why our lime consumption per ton of moisture-free liner as shown on the sketch increased after the flash drying system was installed. I can assure you that our system losses have not increased; instead, they have progressively decreased from about 20 to 10 lb. per ton as CaO. The real reason for the increased consumption of lime per ton of pulp produced is that our cooking cycle in the digesters was deliberately shortened to provide more pulp production. This speeding-up of the cooking process required more active alkali to offset the reduction in time, thus our use of active alkali per ton increased, which required a proportionate increase in lime for reconstitution of the increased liquor flow. (If this sounds confusing to you, try explaining something like this to a visitor sometime, or better yet, to a nontechnical member of your Board of Directors as he makes his annual mill visit.)

Our general conclusions are, therefore, that the flash drying system not only enabled us to double our lime reburning capacity, but we have accomplished this capacity increase with greater thermal efficiency and far less maintenance and operating costs than we feel would have been experienced had we installed another kiln of the same capacity. As you can see from the samples of kiln feed and reburned product, an essentially powdered and moisture-free material is fed to the kiln while a pebble of quite satisfactory size and reaction characteristics is discharged from the hot end of the kiln. One of our problems that had to be overcome before we could successfully operate this system dealt with convincing all concerned that it shouldn't necessarily be operated exactly like all of us had seen kraft mill lime kilns operated before. Probably our biggest problems, however, were concerned with dust accumulations in the dampers and ducts, but through progressive steps to eliminate the causes of these build-ups, we have achieved a measure of lime reburning and dust collection efficiency that we are, quite frankly, eager to point to with pride.

Presented at the meeting of the Pacific Section of TAPPI, held in Salem, Ore., Nov. 16, 1960.

Kalamazoo Valley

A total of 160 attended the joint Michigan Division of PIMA and Kalamazoo Valley-TAPPI afternoon-evening session of Nov. 16, 1960, at the Hotel Harris. The general theme of the meeting was "The Machine Room."

The afternoon session was chairmaned by Robert W. Hagemeyer, Wyandotte Chemical Co., who introduced Joseph D. Parker, Beloit Iron Works. Dr. Parker discussed "Recent Theoretical Work in the Area of Sheet Formation."

The evening session was chairmaned by Preston Carter, KVP-Sutherland. Paul Petzold, assistant vice-president, Oxford Paper Co., discussed "Upgrading Machine Room and Stock Preparation Equipment for Increased Productivity." Mr. Petzold, in particular, discussed this subject from the point of view of improving existing installations with modest capital outlays.

Presentation of the annual F. C. Boyce Student Award for outstanding achievement was made by Thomas Coldeway, president of National PIMA to Timothy K. Estes, junior student, Paper Technology Dept., Western Michigan University.

Upgrading Machine Room and Stock Preparation Equipment for Increased Productivity

Paul Petzold

I was asked to speak on the subject of "Upgrading machine room and stock preparation equipment for increased productivity." In other words, what can be done to an existing installation to obtain increased production without completely rebuilding it.

Management is or should be continually reviewing its operations in order to keep production and efficiency at as high a level as possible. Today's market conditions make these objectives more important than ever. Labor rates, commodities, machinery, and most of the things that go into the cost of making paper are continually rising. To make matters even more complicated, the customer is demanding and is getting improved quality. All these things affect manufacturing cost in the wrong direction—upward! On the other hand, overcapacity in many areas of our industry has operated to prevent selling prices from rising. This has put an uncomfortable squeeze on profits and earnings.

This squeeze has been going on for the past 10 to 12 years and we are gradually coming to a point where we must take serious steps to correct the condition or get into trouble. Increased production will help to offset increases in costs. Often, modest increases in speed and consequent increases in production can be obtained by the addition of small components or relatively minor changes. This is certainly not a new approach and you undoubtedly have this under consideration all of the time.

One does not start on this sort of endeavor, however, without some sort of plan. One essential is to get the facts—all of the facts. A good method of getting all of the facts is to prepare a complete analysis of each machine from stock preparation to the winder. Each significant grade or weight produced should be completely catalogued including furnish components, freeness at various points, operating conditions throughout the machine, and all tests made on the paper as

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compared with standards. In addition, one must know the potential demand and whether the market can absorb the additional production.

In order to obtain a complete picture, one should have these figures prepared covering the period of at least 6 months. Conditions may be different in summer than in winter. Variations in clothing conditions also affect results.

The accumulation of these data will require a little time, but in many cases, it can be prepared from past operational records. It is as essential and will bring out features that were not recognized previously.

To illustrate the point, in one mill not long ago, it was felt that a particular machine needed additional steam pressure in the driers to increase speed. Additional steam pressure required expensive changes. Analysis of the facts showed this to be true in some instances. However, this was only true for a relatively small portion of the total production. A significant portion of the grades made were run at less than top speed because of refining limitations. Attacking the refiner problem first produced more returns than a speed up by additional steam supply.

Let's assume that you have completed an analysis of the normal order sheet on a machine that makes a number of grades and weights. Also that it is in a mill using deinked stock and purchased long fiber as main components.

This mill uses beaters to slush the purchased fiber and blends with the short fiber at this point. Some work is done in the beaters and the balance in several jordans. With increased speed, refining becomes a bottleneck. A simple solution might be to install an additional jordan, refiner, or beater. This takes capital and adds power. An additional beater might also add labor.

Since a portion of the furnish is deinked stock, it should not require further treatment. One solution might be a metering system which would permit slushing and refining of the purchased fiber separately. The existing jordans would have the necessary capacity to do more work on the smaller quantity of long fiber requiring it and the other components can be metered in just before going to the machine. With good consistency control and modern magnetic flow meters, it is possible to get as accurate metering as one formerly obtained with batch measuring equipment. In some respects, it is also more flexible than batch control.

The beaters themselves may lack capacity or be costly to operate manpower-wise. A Hydropulper or similar modern stock slusher may do more work with the same power and less labor. One other advantage of a pulper is that the batch can be dropped to a receiving chest at controlled consistency—an additional aid to uniformity.

It may be that refining equipment other than jordans would provide the additional treatment required to obtain the desired objective. Trials of various types may be desirable before final conclusions are drawn.

As production goes up, machine screens sometimes become a bottleneck. The modern Selectifier or Centri-screen has become a popular solution to this problem. In addition, reduced maintenance, a closed system to minimize air entrainment and a reduction in fresh water for showers become side benefits which are very significant.

The use of this type screen also permits location in the basement or to one side of the machine. This can be of assistance if one wishes to lengthen the wire for improved formation at higher speed. Or the fourdrinier and presses can be moved back to permit the installation of driers for added capacity.

When machines are speeded up, the headbox, slices, and forming table become a real problem. Even increases of 50 to 100 ft. change conditions radically enough to require considerable study. In order to control flows adequately to obtain good formation and required sheet characteristics, new approaches are necessary.

At speeds of 300 to 400 f.p.m., it was relatively easy to have slices and aprons adjustable to produce the required results. This statement should be qualified because it required the skill of a good papermaker to produce results. Many gadgets were used. Such things as perforated boards and racks were used to improve distribution. It was not unusual to find a brick or a press weight in the pond ahead of the slices to control currents.

With increased speeds, headboxes need to be redesigned with approach velocities controlled, passages and size proportioned to eliminate channeling and cross currents. Above 600 f.p.m., there is an advantage in using pressurized boxes to reduce pond depth and permit control with perforated rolls.

You have probably read the series of three articles by Brewden and Locking in the August 1st, 8th, and 15th issues of the *Paper Trade Journal*. There is a lot of worth-while information in these articles for anyone considering a change in headbox design.

Control of the stock on the wire also becomes of increasing importance. Forming boards, grooved rolls to control drainage, and deflectors to prevent throwback are aids which are being used more and more frequently.

Heavy weights have been a problem particularly because of the drag on the suction boxes. Roto belts in place of the dry boxes have been of advantage to minimize this in addition to improving wire life.

As speeds go up, the suction couch should be studied. Present-day thinking indicates that additional vacuum pump capacity is required. Some times lump rolls are used. This tends to bring the sheet to the first press with less moisture and also makes it easier to handle. In many cases the couch can be raised to provide more forming spaces or room for more boxes. Wider boxes, to reduce vacuum on individual boxes, are also used.

At this point, one should consider the paper machine drive, its capacity, its stability at the various sections and as a unit.

If the drive is loaded to near capacity, speed becomes more difficult to control. In one case on record, a machine running at 500 to 600 f.p.m. had difficulty with control to the point where speed was reduced 30 to 40 f.p.m. to provide safe operation. A new larger drive was installed and this machine then was operated at 600 to 700 f.p.m. At this point, the headbox and slices then prevented further speed up. A new pressure headbox and slice promises to give additional speed up to the point where the winder can no longer handle the production.

Control of speed between sections, particularly at the wet end, is quite important. Deficiencies here will be multiplied as speeds go up. Variations should be checked carefully.

Control of pressing also becomes more important as speeds go up. A majority of the machine nowadays are equipped with suction first presses and at speeds above 600 f.p.m., suction second presses should be considered for maximum water removal.

Experience with one machine which was operated with a suction first press and plain second press indicated a limit of 650 f.p.m. on a given weight of paper. After a suction second press was installed, the same grade and weight could be run at 800 f.p.m.

In this particular case, the plain second press removed very little water. Tests showed practically the same moisture on leaving as on entering the press.

Every pound of moisture removed at the presses pays big dividends in reduced drier requirements. Unfortunately, the particular orders run on a machine sometimes prevent you from achieving the best or most efficient drying conditions. Sometimes high bulks are required, press pressures have to be eased, and on occasions even a whole section has to be skipped. If this happens only occasionally, reduced speeds have to be accepted. However, if this grade represents a major part of the order makeup, it should be recognized.

Adequate provision should then be made to provide additional drying.

The drier section generally represents one of the biggest bottlenecks in achieving higher speeds. This is particularly true of older machines which have been speeded up a number of times during their life.

In the first instance, a good drier section needs a good steam control and evacuation system. There are a number of good ones on the market and it is not intended to argue the merits of any particular one. The main point is having a good one and then keeping it good. If it is not maintained properly in all its phases—from control instruments to syphon pipes and steam joints—you finally run into grief. Machine speeds drop off and comments are heard about hard drying and associated problems. Some of these can stem from poor press performance or old felts. Most frequently the trouble will be traced to the drying system. After correction, you will find the machine again running at its normal speed.

Should the analysis indicate lack of drying capacity, how to attack the problem? Adding driers would be a simple answer. Many mills don't have the room to do this and have to take some other approach.

Felt driers can sometimes be added in sufficient number to provide the necessary added capacity. These are generally more easily installed on the top or upper felt. Pit construction sometimes interferes with felt driers on the bottom felt. In this case, heated air blown on the felt through duct work will do the job equally as well. Condensate from the driers can be used to help heat this air cooling it sufficiently to aid in obtaining vacuum to evacuate the driers.

Sometimes increased pressures can be used providing the mill steam balance will permit. However, many driers today are limited in steam pressure by the insurance companies because they have not been manufactured or tested under code. Occasionally the drier section can be arranged to use higher steam pressure in one section only and new driers installed to handle this pressure. This arrangement will work, but it requires a more complicated control.

There has been considerable interest in the industry concerning high velocity air drying. Indications are not altogether clear as to whether it is completely successful on the wet end driers. Successful installations, however, have been made midway in the drier section. These have materially augmented drying. Controlling the flow of air across the face of the drier has also been very helpful in controlling across the web moisture. It goes without saying that uniformity of drying is desirable for good quality. Uniform drying also permits operation closer to the top limit of drying capacity. In some cases, this can mean an increase in speed.

Today many machines are being equipped with size presses. These units increase the flexibility and permit the manufacture of grades that formerly could not be made without them.

In addition to new grades, a size press can help to improve grades made presently without one. The use of a surface sizing can produce internal bond which was formerly obtained by additional refining and the addition of starch at the beaters. By cutting back on the refining, freeness is increased and water can be more easily removed at the presses and in the drier section. An increase in speed is then possible if these factors have been the bottleneck.

A size press in general assists in removing stresses set up in the paper in the drying operation. Practically all grades are benefited by this operation even if warm water only is used at the press. Water leaf or carbonate filled papers are the exception because they are difficult to handle through the press.

Again, if one wants to have a high moisture in the paper leaving the machine, this can be more easily done with a size press. Paper going to the size press can be dried out sufficiently to minimize the effect of damp streaks across the web. Water applied at the press and left after the size driers will in general not blacken the sheet in passing through the stack.

Space for the installation of a size press is generally a problem in an older mill. All sorts of ingenious arrangements have been used to squeeze one in the space available.

Here in Kalamazoo you have an installation of an upside down press to achieve this purpose. In other mills, presses have been located in the basement or driers have been triple decked.

High velocity drying after the size press has been used in several instances to reduce the number of driers after a size press. To date, indications are that these installations are successful.

In certain circumstances the use of sweat driers is desirable in the drier section after the size press. They can be used to control curl but they do have the disadvantage of taking up space that could be used for drying.

As we increase speed, control of calendering becomes more difficult. This means more air and at higher pressure. In many cases, extra cooling or even refrigeration may be necessary. Some mills have used steam in bored intermediate rolls to heat the stack in order to make the air more effective.

Again as we increase speed, wear on the stack increases so that more frequent grindings are necessary. If facilities for grinding are limited, additional spares must be kept available.

Today we have two rather new tools for the control of paper leaving the machine. One is the caliper profiler which can give the operators a good indication of the uniformity of the paper caliper across the web. We also have across the web basis weight scanning devices manufactured by such companies as Industrial Nucleonics, Tracer Lab, and Curtiss-Wright. The proper use of these two instruments should enable the operators to produce a level sheet of uniform basis weight.

It cannot be too strongly pointed out that the above instruments or any others installed on the machine will be only as effective as the condition in which they are kept.

If the equipment functions perfectly all of the time, the operators will gain confidence in it and use it. If not, the equipment will slowly lose its value and finally be removed or left to collect dust because the operators will not use it.

If conditions are such that the instruments cannot function to good advantage, such conditions should be corrected as soon as possible. Also, extensive training should be provided so the operators understand what the instruments are supposed to do and how they function.

Too many times have we bought control equipment with high hopes for improvement in our quality or uniformity and lost the value because of a lack of proper attention soon enough. Once the equipment is installed, it becomes all too easy to go off on some other problem believing this one is solved.

Sometimes one also tends to think only in terms of the gains to be made by the use of this or that control or piece of instrumentation, forgetting or neglecting the cost and time required to keep it in operating condition.

You would have difficulty in making paper if your jordan tackle or wires or felts were not in good condition. By the same token, your quality will not be up to standard if you don't keep your instruments in A-1 condition.

The things mentioned are just high lights of things to be done to upgrade machine room and stock preparation equipment. Every move has to be taken with considerable thought as to its effect on the overall results. More than ever, we have to gage every expenditure by the return it makes. Get the facts—all the facts—use them wisely and generally you can obtain a return which helps to improve overall operation.

Presented at the meeting of the Kalamazoo Valley Section of TAPPI, held in Kalamazoo, Mich., Nov. 16, 1960.

New England (Bay District)

On Monday, Nov. 14, 1960, 300 members and guests attended the Bay District's meeting at Armand's, Beacon Terrace in Framingham to hear Professor Stuart U. Rich of the Harvard Business School speak on "Achieving Success in Specialty Papers" (page 22A). It is believed that this is the largest meeting ever held for a single district within New England TAPPI.

A panel of four well-known New England paper mill executives, George Wallace III, president of Fitchburg Paper Co.; Bartow Kelley, treasurer of Crocker-Burbank Co., Assoc.; Amor Hollingsworth, president of Tileston & Hollingsworth Co.; and Norman Bearse, mill manager of Oxford Paper Co., Lawrence, Mass., gave their comments on Professor Rich's conclusions.

Mr. Bearse summarized the first three panel members' thoughts by saying that Mr. Wallace approached the ultimate goal through strong management, Mr. Hollingsworth pointed to the use of profits of the nonintegrated mill, and Mr. Kelley pointed out the versatility of the nonintegrated mill.

D. W. Lovering, *Secretary*

Banquet speaker, John H. Heuer, vice-president and manager of manufacture of Great Northern Paper Co.

Maine-New Hampshire

Surface Treatment of Paper and Board with Starch and Pigments

J. E. Killinger and John P. Bainbridge

This discussion of surface treatments will cover size press and calender sizing, size press coatings, and, to a limited extent, wet end coatings based on starch and starch derivatives. No attempt will be made to cover true coating procedures such as roll coatings, air-knife coatings, trailing blade coatings, and similar techniques. A one-half hour talk is hardly long enough to cover the field of surface treatments on the paper machine, and it is my plan, therefore, to stick to a few of the more important fundamentals of this very broad subject and to discuss some of the special materials and techniques which have been developed recently.

First, let us look at the reason paper and paperboard are treated at the size press or calender stacks. We might say that the first reason is to improve the physical tests of the paper. This would include increased strength and possibly increased resistance to the passage of liquids or gases. The second reason is to improve the surface of the sheet—that is, to lay the fuzz, increase the smoothness, affect the ink absorption, increase the brightness or appearance, et cetera.

In order to improve the dry physical tests of the paper or paperboard, we would, of course, use a nonpigmented size. To improve the surface, we might use a nonpigmented size or a pigmented coating. If the treatment is mainly to lay the fuzz and keep the printing inks on the surface, then a pure starch solution would be indicated, but if we want to whiten the surface, improve opacity, impart ink absorption, and, particularly if we want to fill in the hills and valleys inevitably encountered in the paper, then a pigmented coating is necessary.

J. E. Killinger and John P. Bainbridge, Penich & Ford Ltd., Inc., Cedar Rapids, Iowa.

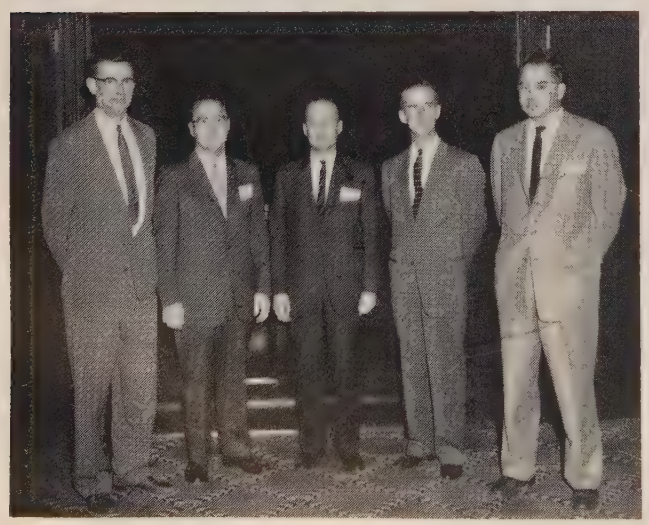
Head table: Malcolm White, Oxford Paper Co.; Mrs. Malcolm White; Mrs. Donald Bail; Donald Bail, Great Northern Paper Co.; Mrs. Bartlett Taylor; Bartlett A. Taylor, James A. Taylor & Son; Mrs. Walter Wood; Walter Wood, Jr., National Aniline Div.; Mrs. John Heuer; John Heuer, Great Northern Paper Co.

Head table: Edward Poor, Hudson Pulp & Paper Co., Section Chairman; Mrs. Edward Poor; H. Whitney Osgood, S. D. Warren Co., Section Vice-Chairman; Mrs. H. Whitney Osgood; Lawrence Adkins, Waterfalls Tissue Corp.; Mrs. Lawrence Adkins; Harold Pratt, Pejepscot Paper Co., Section Secretary-Treasurer; Carl Perkins, St. Regis Paper Co.; Mrs. Carl Perkins

SURFACE SIZING TO IMPROVE STRENGTH

There are several means by which the papermaker can improve the strength of his paper. These include the selection of pulp, hydration, the degree of sheet formation, basis weight, wet end or furnish additives, and dry end treatments. The choice between adding a furnish additive and a surface treatment must be based upon the particular machine situation, but it is quite obvious that a dry end treatment has one big advantage in that all of the material added is retained 100%. This is usually not the case in wet end addition where a retention on the order of 50% is the general rule. Surface treatment for increases in strength has, therefore, a real economic advantage, particularly as many of the other means previously mentioned involve a slowing of drainage or drying rate. It is true that a size press treatment involves re-drying the paper, but in many instances this is less a problem than is the problem of water removal on the wet end created by increased beating and/or the use of additives.

When we want to apply a size press treatment with a minimum of effect on the surface and a maximum improvement in physical tests, we must insure as complete penetration of the size into the paper or paperboard as is possible. To do this, we want to keep the solution as hot as practical. We recommend temperatures for the size press solution on the order of 170 to 190°F. if the equipment will permit. A depolymerized starch product is necessary so that solutions of high concentration will be thin enough to be handled and to penetrate through the paper. Cornstarch, very much like cellulose from wood, is produced by nature having a high molecular weight long chain. During the refining of cornstarch, or, for that matter, any of the starches, the chain length is not appreciably shortened. The starch molecules are separated from the protein, fiber, and oils in the corn kernel so that a white pure starch product is obtained, but during this separation no chemical reaction takes place in the starch itself. Such a refined product is pearl or native starch. Its viscosity is much too high for efficient penetration into the paper, so it is usually modified by one of several techniques. Until recently, the thinner-bodied starches were produced by breaking the chain length by one of several techniques. These include enzyme conversion which does an excellent job but is rather difficult to control under the best conditions. The thin boiling starches produced by the manufacturer are obtained by acid depolymerization. The oxidized or chlorinated starches are depolymerized by either an acid or alkaline oxidation. All of these methods are used with various degrees of success.



Technical program speakers, left to right, H. Whitney Osgood, Moderator; E. J. Barber, Hercules Powder Co.; R. B. Teeple, Jr., Hercules Powder Co., Walter Reynolds, American Cyanamid Co.; Paul Shirley, Penick & Ford Ltd., who read the paper prepared by John Bainbridge of Penick & Ford Ltd.

Edward Poor, Section Chairman; Harold Pratt, Section Secretary-Treasurer; H. Whitney Osgood, Section Vice-Chairman; Lawrence Adkins, Publicity Chairman

The question is, to what extent should the chain length be broken? If the viscosity is reduced to too great an extent, the strength of the starch, itself, is materially reduced; therefore, more of the weaker starch would be required and the costs would be increased. There is, therefore, an important balance between reduction in viscosity, desired increase in strength, and the cost of the treatment. A situation can be envisioned in which the inherent starch can be so weak that a high pickup would be required. This, in turn, would require reducing the viscosity which, in turn, would reduce the strength of the starch; consequently, the cost of such a treatment would be exorbitant and the amount picked up would be so great that undesirable sheet properties might be obtained. The chemically derivatized starches yield maximum film strength, and are, therefore, found to give maximum economy and performance.

The papermaker has available several chemically derivatized natural or modified starches at costs per pound only slightly above those of the native cornstarches. These include the starch hydroxy ethyl ethers, starch acetates, carboxymethyl starches, and other starch esters. These products are available over a large viscosity range just as are native cornstarches. The main advantages, particularly of the starch ether, are the improved film strength, film clarity, high bound water content, increased reactivity with resins, and ease of handling due to the reduced tendency to set back or gel which these products exhibit. The latter is particularly important since solutions of higher viscosity can be applied than is possible with materials exhibiting greater setback properties. In addition, the starch ethers have an advantage in that they are more resistant to biological spoilage than are underivatized starches.

For increased strength on paperboard where a size press is not available, applications can be made at the calender stacks where about one-half or two-thirds the pickup realized at the size press can be obtained. Again, it is important that the solution be maintained at high temperatures and that a strong but fluid product be chosen. Solutions as high as 20 to 25% have been successfully applied at high speeds, both from a size press and from a calender stack.

SIZING TO IMPROVE SURFACE CHARACTERISTICS

The improvement of surface characteristics, as we mentioned earlier, depends on keeping the coating or sizing on the

surface and forming as continuous a film as is possible. The product to use is one giving a much higher viscosity than desired for internal effect and yet it should be a good film former. Lower application temperatures are usually indicated although, again, high temperatures permit the handling and selection of high solids sizings which otherwise would not be applied. Good film strength in the product to be selected is of major importance. The higher substituted hydroxy ethyl ethers are particularly valuable for this reason, and because of their specific properties are frequently found to be less expensive per pound of paper than the lowest priced starches or flours.

Surface Sizing for Gloss Ink Printing

The starch ethers are very satisfactory for the treatment of paper or paperboard where high gloss ink printing is desired. Furthermore, the starch ethers are compatible with the various gums such as CMC, alginates, and polyvinyl alcohol which are sometimes used in small amounts with them. As a general rule of thumb, it is obvious that the high viscosity starch ethers should be used at the lowest possible application temperature.

Commercial runs have been made in several mills in which solutions of as high as 22% of a fluid starch ether did not yield as high gloss ink printing results as did 5 to 6% solutions of medium or lower viscosity starch ethers which stayed on the surface better, thereby doing a more efficient job. It is obvious that there is a big savings possible by selecting and using the higher viscosity products where a surface effect such as gloss ink printing is required.

It has often been demonstrated that several treatments are more effective than one just as are two coats of paint more effective in painting a house. When it is practical to do so, treatment at the size press followed by subsequent treatment at the calender stacks is desirable. Improved printing results with less add-on are possible by the multiple application technique.

Starch Ether Complexes

After a considerable amount of research and development work, we have been quite successful in developing a new and somewhat novel process for further improving the advantages to be realized by employing starch ethers as surface sizes. This process involves the complexing of a starch ether with a high stearin soap and subsequently precipitating it as an extremely colloidal solution. The solution so prepared resembles a blue-white wax emulsion in appearance, is pure white in color, and is extremely stable. By incorporating stearin into the starch ether, we greatly increase the water-resistant properties, improve gloss, increase grease resistance, and appreciably increase scuff resistance. The starch ether is first heated to 195°F. in the required amount of water, after which from 5% to as much as 40% of a high stearin soap is added, the percentage of soap being based on the dry weight of the starch ether. At high temperature, the soap will complex with the starch ether, and if it be acidified while still hot with an alum solution, a starch-stearin-alum complex precipitates immediately in a very colloidal solution. Under some conditions, one would not wish to employ a surface size having an acid reaction, and for such applications the alum which is used to precipitate the complex may be replaced with a soluble calcium salt such as the chloride. To obtain maximum colloidality, it is essential that the precipitant be added while the solution is still at or near 195°F., after which it may be diluted and used or stored at any desired temperature.

When preparing this type of size, it will be noted that immediately after the soap has dissolved and complexed with the starch ether a very pronounced increase in viscosity takes place and the size has a pronounced tendency to foam and froth. However, after the precipitant is added the solution turns pure white, loses all tendency to froth and foam, and the viscosity returns to that of the pure starch solution. This process is being used very successfully today in the production of tabulating cards which have exacting specifications with reference to static and dynamic friction, for envelope paper, tablet stock, file folder, linerboard, and other production where an exceptionally smooth high finish is desired. I would like also to point out at this time that water and all starch solutions when applied at the size press or on a calender stack usually result in a loss of 1 or 2 points in brightness. The above process will usually show a pickup of 2 or 3 points in brightness compared to other starch and water solutions even when starting with high brightness pulp.

We think you will also be interested to know that the starch-soap process may also be used with urea formaldehyde or melamine resins to further increase water resistance and both wet and dry scuff.

Antisticking Agents

There are three basic types of antisticking agents—soaps, wax emulsions, and the polyethylene glycols. All of these are effective antisticking agents and all are used commercially.

The soaps tend to increase the viscosity of the size and sometimes form scum due to hard water precipitants. The wax emulsions are not as susceptible to the effect of water but on occasion do increase the viscosity slightly, and precautions must be taken to insure that the emulsions do not break during precipitation or use of the size. Like the soaps, the waxes are soluble in fats, waxes, and oils.

The polyethylene glycols are enjoying increased favor. They are not sensitive to the hardness of the water, do not increase viscosity, and are, of course, insoluble in oils, greases, or fats. Therefore, where we want grease resistance, we would use the polyethylene glycols, and where we want water resistance, the waxes and soaps are indicated. For papers and boards requiring good glueability, a water-sensitive material like polyethylene glycol would be preferred.

SIZE PRESS AND CALENDER COATINGS

The coating of paper or paperboard at the size press or at the calender stacks is becoming more important all the time. It is a very broad subject and, again, it would be impossible in a talk of this scope to cover the subject in any detail, but an effort will be made to cover a few of the fundamentals.

On paper, size press coatings are being run at anywhere from 15 to 50% solids and at adhesive ratios from 20% to well over 100%. Obviously, if a size press coating replaces a straight size press treatment, the improvement in strength normally obtained with the latter will be sacrificed. Therefore, a high adhesive ratio is necessary not to bind the pigment but to permit both effects to be obtained—that is, good pigment binding and dry strength improvement.

Speeds at which both paper and board are being coated range from a few hundred feet per minute to over 1400 f.p.m. There seems to be almost no limit to the speeds which can be obtained, and we are constantly being surprised by reports of the high viscosity, high-speed size press coating which is being done.

Coat weights being applied at the size press vary anywhere from 2 to 20 lb. per ream. On offset grades, water resistance or wet rub resistance may be necessary. It has been found that when lightweight coatings are applied, that is, below 4 lb. per ream, it is not necessary to impart any water resistance since the coating cannot be rubbed off even under wet conditions. Apparently, most of the coating is down among the fibers and is not easily removed.

For papers to be printed by the offset process, it is very important that the coating be water resistant when the coat weights are higher than about 4 lb. per ream. There are several ways of obtaining such water resistance, including the use of urea or melamine resins, the addition of wax emulsions, the starch ether-soap complex, or the addition of synthetic resin emulsions.

Conditions in size press coating of offset grades are ideal for the development of wet rub resistance with urea or melamine resins. The base stock for offset printing is almost always sized and therefore is acid. No acid is required to catalyze the reaction of the urea formaldehyde and melamine formaldehyde resin and the starch product. Consequently, there is no adverse effect on flow properties of the clay coatings as does occur when acid or alum is added to a clay slip. There are usually 12 to 14 driers after the size press to help set the resin, and usually the paper is rolled up hot and remains so for several hours completing the cure. A minimum of resin is required—that is, 5 to 10% on the weight of the starch product. Incidentally, the hydroxy ethyl ether starches are much more reactive to urea and melamine resins, and their use is, therefore, very desirable in this type of coating. In addition, of course, these products impart improved pigment binding and better ink holdout and as a result of requiring less adhesive, improved color and gloss are usually obtained.

Water resistance may also be obtained by the addition of wax emulsions and, as previously stated, by the use of the starch ether-soap process. The degree of water resistance required and the other properties of the coated paper desired usually determine which of the several methods for obtaining water resistance is selected.

Where some water resistance is required and where other properties make it desirable, mills use synthetic resin emulsions with the starch product. Styrene butadiene, acrylic, and vinyl acetate emulsions have all been used successfully. Generally speaking, 20 to 25% replacement of the starch product with the resin emulsion is minimum for improved wet rub resistance. Many mills are using 50% resin solids on total adhesive for size press coating offset grades. Others make similar grades with no resin emulsion. One paper company having several mills produces the same grade of paper at two of their divisions. One mill uses 25% resin in the adhesive; the other uses a straight hydroxy ethyl ether starch. The research department and the sales department of this company can see little difference between the two sheets and both are being sold regularly.

Incidentally, many mills introducing grades of paper coated at the size press which replace straight size grades have encountered objections by their sales department to the reduced pick test number. On investigation, these complaints have never been justified since experience has shown that a water-resistant size press coated paper with a fairly low wax pick test prints just as well on an offset press as does an unpigmented sheet having a much higher pick test. Furthermore, such a sheet prints much better than would a nonwaterproof coated grade having much higher wax pick test. Water resistance, therefore, seems more important than an unduly high pick test.

The problems involved in size press coating of board are similar to those of coated paper except that the resin emulsions may not be necessary or desirable. Most manufacturers of food grade board are presently applying at the size press and at the first calender stack very high viscosity, hot solutions of hydroxy ethyl ether starches with or without pigments. When water resistance is required, a final coating is applied between of after the calenders using resins or proteins as the binder.

Folding boxboard grades are also being coated at the calender stack and interesting and unique paper properties obtained. Some of the coatings are designed to give a more uniform lightness or brightness to the folding grade. Other mills are applying calender coatings to give a mottled effect which, surprisingly, their sales departments have found quite attractive. Still other folding boxboard mills have applied coatings to improve the printability of their grades, including improved butyl carbitol tests.

WET END COATINGS

Both paper and board are also being coated at the wet end of the paper machine. These techniques are very varied depending on the particular mill setup and paper properties required. Coatings are being applied to paper at the dandy roll using special techniques developed for this purpose. Pigmented coatings are also being applied commercially at the first and second presses and at the smoothing press. Frequently, such treatments are followed by additional size press and/or calender stack coatings. In effect, therefore, several coats are applied and smooth even effects are being obtained even where the equipment is not originally designed for coating application.

One technique that has proved very useful is in the application of wet end coatings in which part of the starch is not completely cooked out. One of the problems involved in wet end coatings is that of the coating sticking to the rolls causing breaks or poor quality coatings. If the amount of adhesive is reduced sufficiently to eliminate the sticking, then the coating is not sufficiently well bonded to permit subsequent operations. A technique which has been developed depends on the low gelatinization temperature of the high substituted starch ethers. These have a gelatinization point from 20 to 25°F. lower than does an unmodified and natural starch. Therefore, coatings in which only 10% of the starch is cooked can be applied at the dandy roll or at the size presses, and during the drying operation the gelatinization temperature is reached while there is still sufficient moisture at the surface of the paper to permit swelling of the remainder of the starch. With regular starch, however, the sheet would be too dry by the time the starch reaches the gelatinization temperature and it would never be able to swell and act as a binder. Such coatings are finding commercial application in the wet end coating of insulating board and other heavy board grades.

SUMMARY

In summary, we can restate a few of the principles discussed above. When increased strength of paper or paperboard is required, a hot unpigmented solution should be applied that is fluid enough to penetrate but which consists of a derivatized starch having sufficiently strong film strength for effective fiber bonding.

Improved surface characteristics can be obtained by either an unpigmented starch or derivatized starch application which should be as heavy in viscosity as can be handled and should consist of a good film former. Excellent gloss ink printing can be obtained by use of starch hydroxy ethyl ethers sometimes blended with a small amount of an alginate, CMC, or polyvinyl alcohol. The starch ether-soap complex is used for improved surface characteristics, less loss in brightness, control of surface friction, increased water resistance, and ink holdout.

Pigmented coatings are being applied at the wet end of the paper machine, at the size press, and at the calender stacks. When applying pigmented coatings to replace clear solutions, provision must be made for a lower strength improvement which can be expected of pigmented coatings. In such cases, a high adhesive to pigment ratio is desirable. Water-resistant coatings are desirable on offset coated papers when the coat weight is more than 4 lb. per ream. Size press application of coatings offers ideal conditions for water resistance to be obtained by urea or melamine formaldehyde resins. Water resistance can also be imparted by the addition of wax and the synthetic resin emulsions. The starch hydroxy ethyl ethers and other derivatized starches are being used very extensively in the surface treatment of paper and paperboard due to their improved film strength, film clarity, high bound water content, resistance to biological spoilage, increased reactivity with resins, and particularly the decreased setback, reduced tendency to gel and better viscosity stability which these products exhibit.

Presented at the meeting of the Maine-New Hampshire Section of TAPPI, held in Portland, Me., Nov. 4–5, 1960.

Some Recent Research on Accostrength Resin 2386

Walter F. Reynolds

In 1957 we presented a paper at the TAPPI meeting in New York describing a new acrylamide polymer for improving the dry strength of paper. The resin, now known commercially as Accostrength Resin 2386, was described as an anionic copolymer of acrylamide and acrylic acid with a molecular weight of about 250,000. It was tailored especially for dry strength improvement. By changing the carboxyl

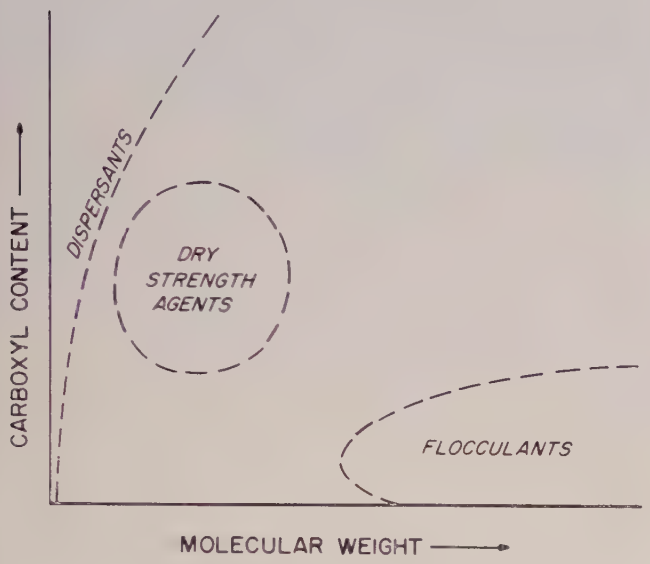


Fig. 1. Applications of acrylamide-based polymers

content (from acrylic acid monomer) and/or molecular weight acrylamide based polymers can be made to behave as powerful flocculating or dispersing agents. This relationship is shown in Fig. 1. The structural formula of an acrylamide-acrylic acid copolymer is shown in Fig. 2.

"POLYACRYLAMIDE"

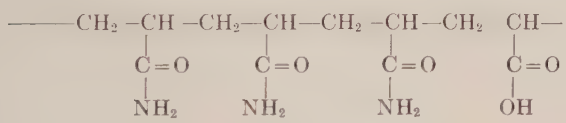


Fig. 2

Accostrength Resin 2386 is a very effective dry strength additive when properly used in conjunction with alum (aluminum sulfate). The strength properties related to better fiber-to-fiber bonding undergo a large improvement. Typical results for three widely different pulps are shown in Tables I, II, and III. In our earlier paper, it was pointed out that the resin provides additional bonds between fiber surfaces where the distance is too great for hydrogen bonding to take place between adjacent OH groups of the cellulose. This hypothesis is illustrated in the schematic diagram in Fig. 3. The most convincing evidence supporting this hypothesis is the fact that the resin can double the strength with very little change in density, porosity, or optical properties (light scattering). It is a well recognized fact that these properties are sensitive to the compactness of the sheet structure and undergo decided change where greater strength is the result of additional beating.

So much for the mechanism of how the resin imparts higher strength to paper. I would like to describe next some recent work we have done to obtain a clearer picture of

Walter F. Reynolds, American Cyanamid Co., Stamford, Conn.

Fig. 3

the role that aluminum salts, such as aluminum sulfate, play in making Accostrength Resin 2386 work.

May I preface my remarks by saying that this study has given us a healthy respect for the colloid chemistry of so-called "alumina floc" and indicates to us that there is plenty left to be learned from future research.

Right from the beginning of the Accostrength Resin 2386 development the importance of controlling the pH of the alum treated stock was recognized as is shown in Fig. 4.

It was thought that the formation of the most favorable alumina floc was simply a function of pH. This was true as long as we used about the same amount of alum and treated the stock at about the same consistency. However, if you take the example where these variables are widely different you have the situation shown in Fig. 5. Here we have plotted dry strength improvement against stock pH. In the case of high alum usage and thick stock, the optimum pH occurred at 4.2. At the other extreme, low alum usage (1.5% minimum) and dilute stock the pH for maximum results were 4.6. Obviously, pH is not the basic factor controlling the formation of the most effective alumina floc.

In Fig. 6, the data in Fig. 5 are replotted against the molar

Table I. Alpha Softwood (G.F.-450 ml.)

Resin added, %	*Tensile, lb./in.*	*Mullen*
None	13.5	21.6
0.25	15.2	27.6
0.50	18.0	33.0
1.00	19.0	36.5

Table II. Bleached Semichemical Hardwood (G.F.-320 ml.)

Resin added, %	*Tensile lb./in.*	*Mullen*	*Tear*	*M.I.T. fold*	*Wax pick*
None	21.4	30.0	50.5	22	10
0.25	25.0	35.0	53.0	57	..
0.50	28.5	44.0	57.5	125	16
1.00	29.0	45.5	55.0	158	..

Table III. Unbleached Northern Kraft (G.F.-620 ml.)

Resin added, %	*Tensile lb./in.*	*Mullen*	*Tear*	*M.I.T. fold*
None	22.4	48.5	90.0	700
0.25	25.8	53.5	83.0	1237
0.50	27.0	60.5	79.0	1370
1.00	28.4	62.5	72.5	1566

Table IV

Mols NaOH per mol aluminum sulfate	*Composition of alumina floc*	*Usefulness of floc*
0	Al^{+++}-no floc	Only partial
2	$Al(OH)^{++}SO_4$	Excellent
4	$Al(OH)_2{}^{+}SO_4$	N.G.
6	$Al(OH)_3$	N.G.

ratio of NaOH to alum, instead of pH. It is now apparent what the basic factor is. In Fig. 6, it will be noted that maximum or near maximum dry strength is realized where the molar ratio of alkali, expressed as NaOH to aluminum sulfate is between 1:1 and 3:1. Below a 1:1 ratio, the floc formed is ideal but is present in insufficient amounts. Much above a ratio of 3:1, or 50% neutralized, more and more dihydroxy alumina floc is formed at the expense of the desirable monohydroxy alumina floc.

For illustrative purpose only, we can visualize the transition stages of aluminum sulfate in the following way (see Table IV). The potentiometric titration curves for the two examples cited above are shown in Fig. 7.

Now in case I have given anyone the mistaken idea that the colloid chemistry of alumina is overly simple, I will attempt to correct this impression by citing a few additional facts we have gleaned from our work.

It makes a difference what anion is associated with the Al ion. Figure 8 shows a comparison of $Al_2(SO_4)_3$ and $AlCl_3$. The same amount of Al^{+++} was employed in both instances. It should be pointed out that the molar ratio in this graph is expressed as mol of NaOH per mol of Al ion and numerically is one half the ratio we mentioned earlier when we spoke of mol NaOH per mol of $Al_2(SO_4)_3$. By using $AlCl_3$ maximum dry strength efficiency was obtainable at as high as pH 5.5, whereas with $Al_2(SO_4)_3$ the upper pH limit was 4.85 under the conditions that existed.

$AlCl_3$ certainly looked much better than $Al_2(SO_4)_3$ for using AR 2386 over a wider pH range. The only hitch here is the disconcerting effect that SO_4 ion contamination can have. In the presence of SO_4 ions the benefits of using $AlCl_3$ is lost and the system behaves as if the $Al_2(SO_4)_3$ had been used.

Another interesting feature about alumina floc that was observed in our laboratory was the effect of what we choose to term—"The pH History of the Alumina Floc." The conditions existing during the time the floc is being formed and the sequence of events involved during and after its formation constitutes the floc's history. A clear example of this effect is what happens when you have an inactive floc with a 5:1 NaOH to alum molar ratio. Whether or not this inactive floc can be restored to the activity of a 2:1 alumina floc depends on how much time has elapsed between the formation

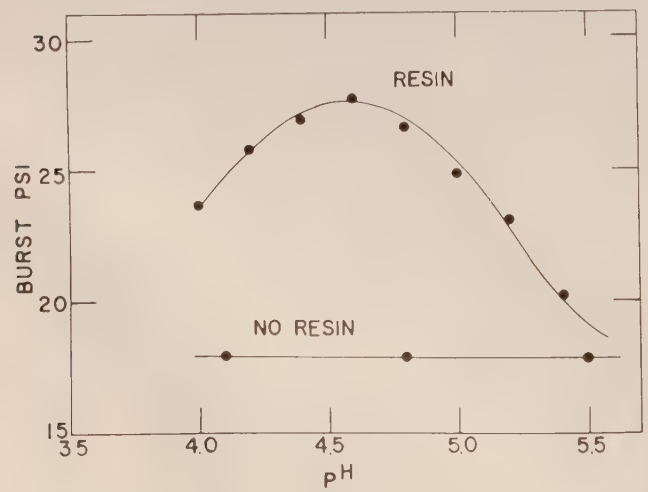


Fig. 4

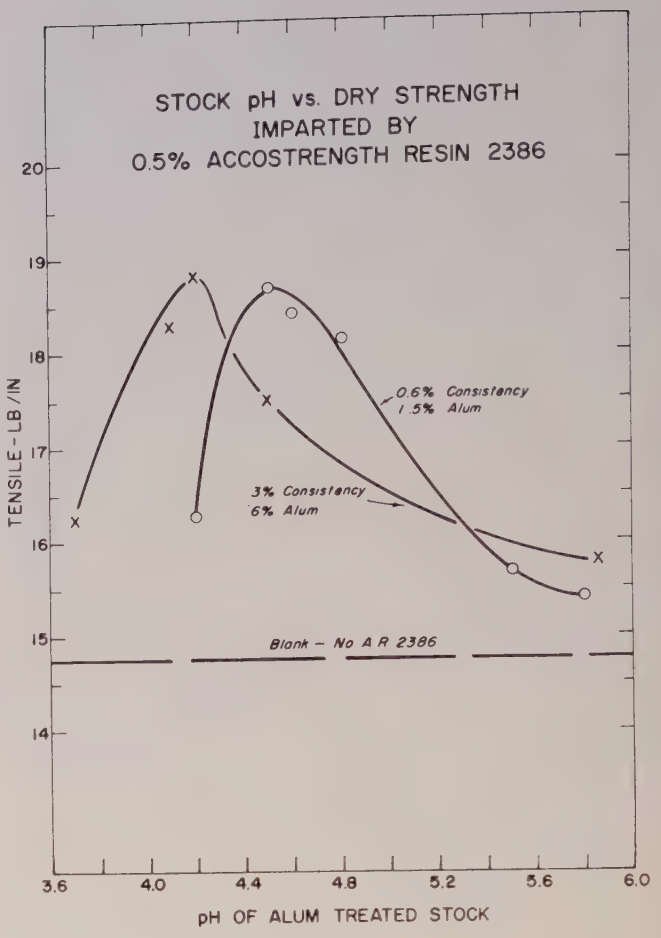


Fig. 5

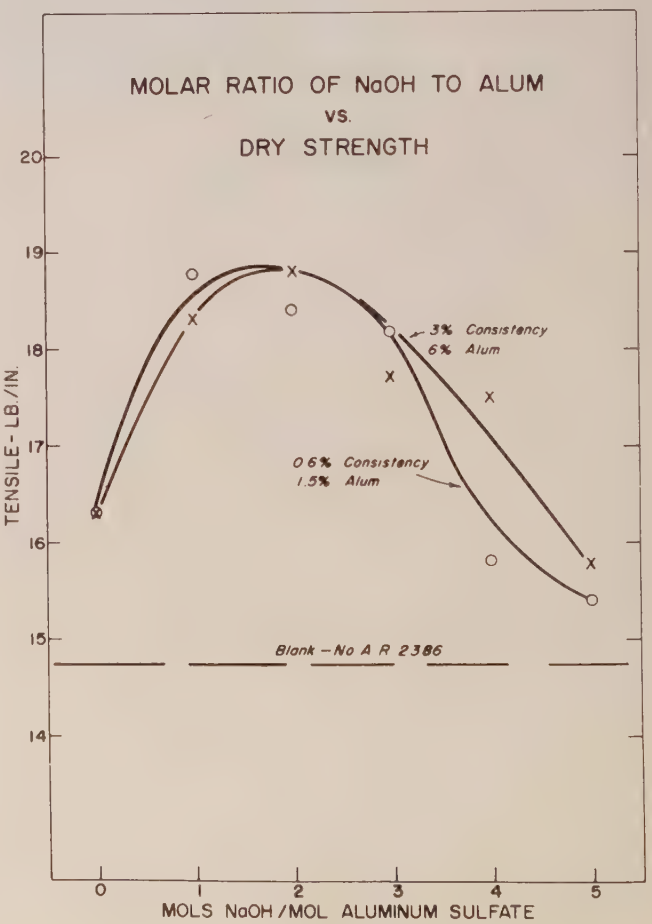


Fig. 6

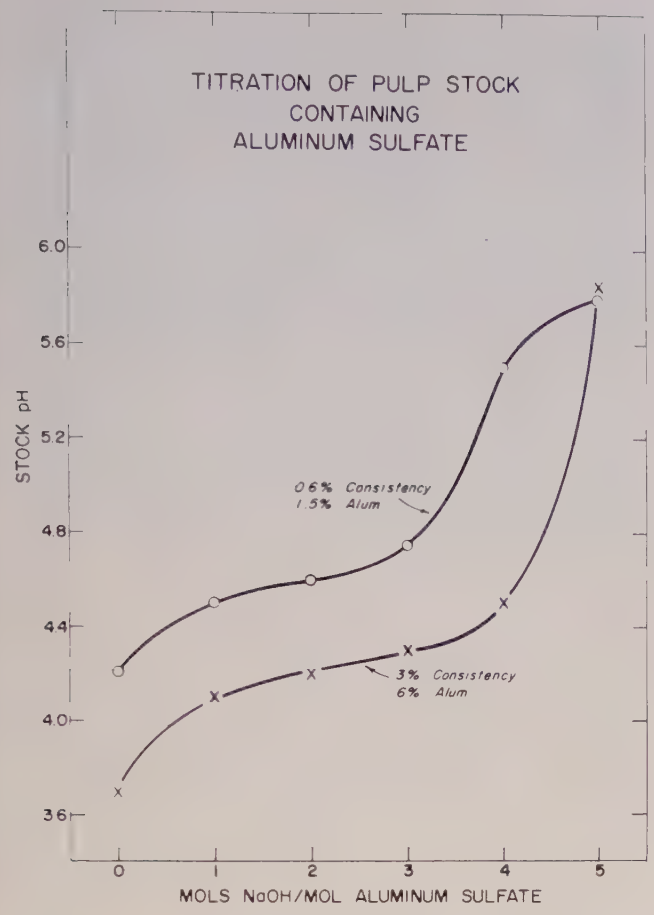


Fig. 7

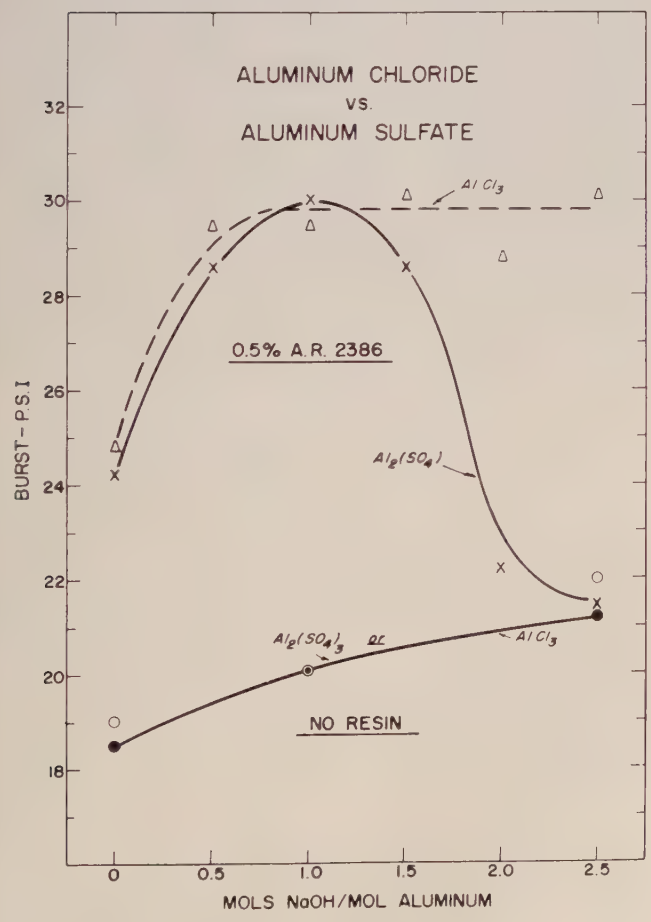


Fig. 8

of the 5:1 floc and the time you treat the stock with acid. If the acid is added within a minute or two the 5:1 alumina floc can be reactivated almost completely. Adequate time, however, must be allowed for the acid to do its job. If the acidification is delayed much longer, the degree to which the floc can be restored diminishes rapidly until after about an hour no effect is noted. In hot stock this time interval would be shortened considerably. Of course, if an excess of acid is used, the floc can be dissolved back to its ionic state and you can start over again to form a 2:1 floc with the correct amount of alkali. The point here to keep in mind is that for all practical purposes, the proper formation of "active" alumina floc is comparable to a one-way street. It should only be approached from one direction—in our case from the low end of the pH scale.

Another example of the influence of "pH history" is what happens when there is a strong buffer present in the stock instead of an alkali like sodium hydroxide, sodium bicarbonate, or rosin size. We found that by using a buffering salt like sodium acetate as the source of alkali in the stock we were able to extend the pH range upward from 5.0 to pH 5.2 at which maximum dry strength results can be obtained from AR 2386.

We feel that what has happened here is that the alumina floc has been formed in the presence of a lower and more constant level of OH ions from the hydrolysis of sodium acetate. As the OH ions are consumed in the formation of the alumina floc, more are made available by the buffer salt. On the other hand, where the system is not buffered and a high concentration of OH exists, the floc formed is not as homogeneous in composition or charge. A tremendous amount remains to be done to clarify the mechanism and behavior of alumina floc. The benefit of this research is clear cut: more efficient use of those paper chemicals that depend on the colloidal behavior of partially neutralized aluminum salts.

Presented at the meeting of the Maine-New Hampshire Section of TAPPI, held in Portland, Me., Nov. 4–5, 1960.

The author wishes to acknowledge the contributions that W. F. Linke, N. T. Woodberry, and E. Strazdins have made to the research briefly discussed in this presentation. Permission of the American Cyanamid Co. to publish this article is greatly appreciated.

CMC as a Paper Machine Additive

E. J. Barber

Internal dry strength additives have an established role in the quest for economical fiber utilization. Exact assessment of their economic worth requires considerable effort, but the important fact is that dry strength additives are producing significant benefits in many mills.

Hercules CMC-IA, a low D.S. carboxymethylcellulose, is one of these dry strength additives. There are two basic reasons for its effectiveness: (1) being made from cellulose, its molecular configuration is close to that of cellulose, and (2) it contains a controllable number of substituent groups which impart water solubility and provide a means for adsorption on papermaking fibers.

The primary purpose of this paper is to discuss CMC as an internal dry strength additive. In addition, some attention will be given to its related functions as a surface-applied additive for dry strength and control of holdout properties, and as a pigment retention aid.

CMC is made in a variety of types to meet the specific needs of each of its paper applications. Its basic properties can be varied (1) by changing the average number of substituent groups per anhydroglucose unit (degree of substitution or D.S.), or (2) by varying the chain length (degree of polymerization or D.P.), or (3) by varying the regularity

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Fig. 1. Flow of a Thixotropic sodium carboxymethylcellulose solution

Fig. 2. Flow of a pseudoplastic sodium carboxymethylcellulose solution

with which the substituents are placed along the cellulose chain. The effect of this third factor (at constant D.S. and D.P.) on solution flow properties, for example, is illustrated in Figs. 1 and 2. Figure 1 shows a granular solution of a CMC with rather irregular placement of substituent groups. Figure 2 shows a very smooth solution of CMC with quite regular placement of substituent groups along the cellulose chain.

CMC—INTERNAL ADDITIVE

Papermaking experiments have established that there is an optimum D.S., D.P., and regularity of substitution for maximum dry strength improvements. These optimum values are a D.S. of about 0.4, a viscosity of 300 to 1200 cp. in 2% solution (a D.P. of the order of 250), and a high degree of regularity in substituent placement along the cellulose chain. Hercules, name for this type of CMC is CMC-Internal Additive or CMC-IA.

Retention

CMC-IA has a high affinity for cellulose fibers in an aqueous system containing normal amounts of papermakers alum. This affinity has been demonstrated by making paper with radioactive CMC-IA added to the stock (*1*). Small patches of fibers were pulled from the finished paper and placed on a photographic film. Energy from the radioactive CMC-IA developed the film and produced striking fiber outlines as shown in Fig. 3. It can be seen from this picture that the fiber surfaces appear to be evenly coated with a layer of radioactive CMC-IA.

Now that we know that the CMC-IA is on the fiber surfaces, the next question is: What is its effect on the strength of the sheet?

Evaluation of Strength Effects

The effects of various papermaking factors on the strength properties of paper have been defined in a practical way by Davison and co-workers (*2*). They have classified the effects of these factors into three categories, namely, power substitution value, fiber substitution value, and property disproportionation value. These values can be used to measure the effects of changes in such factors as fiber furnish, amount of refining, and the use of dry strength additives.

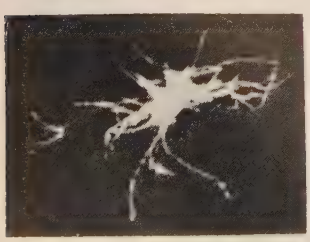

Fig. 3. Autoradiograph

Each of these three types of strength effects can be obtained with CMC-IA as illustrated in Figs. 4 and 5. Figure 4 shows tear-burst plots for bleached sulfite handsheets with and without CMC-IA added. The solid line is a "beater curve" showing the normal increase in burst and decrease in tear with increased beating. The dotted line represents the tear-burst curve obtained with lightly beaten pulp to which increasing amounts of CMC-IA have been added. The four broken lines are constant tear/burst (T/B) ratio lines which emanate from the origin.

Power Substitution Value

The solid line in Fig. 4 shows that increased beating or power input is required to move along the normal beater curve in the direction of lower tear/burst ratios. This pattern of property changes is the normal "strength developing" effect of mechanical refining. A similar effect is achieved by adding increasing amounts of CMC-IA to pulp taken after the first interval of beating. For example, the lightly beaten pulp (1 min. per lb.) plus 0.5% CMC-IA produced a tear/burst ratio equivalent to a beating time of about 2 min. per lb. (estimated) without CMC-IA. Addition of the CMC-IA has produced a power saving of about 50%. Similarly, addition of 1.0% CMC-IA produced a power saving in excess of 65%.

Fiber Substitution

Evidence of fiber substitution value is given in Fig. 4, also. For example, the broken line representing a tear/burst ratio of 2.12 indicates that paper made with 0.5% CMC-IA has a higher level of both tear and burst than the corresponding point on the control curve. The increase in distance along the tear/burst ratio line from the control curve to the CMC-IA curve, as a percentage of the distance from the origin to the control curve, is a measure of the net increase in strength. These increases are 4, 6, and about 18%, respectively, for 0.5, 1.0, and 2.0% CMC-IA added. The 18% value for 2% CMC-IA is of course influenced by the fact that the beater curve is nonlinear here.

These net strength increases can be used to (1) produce a truly stronger sheet or (2) can be translated into fiber substitution value by reducing the basis weight or by substituting lower cost fibers.

Property Disproportionation

The property disproportionation value obtained with CMC-IA in the experiment in question is shown in Fig. 5. The solid line shows a normal increase in burst and air

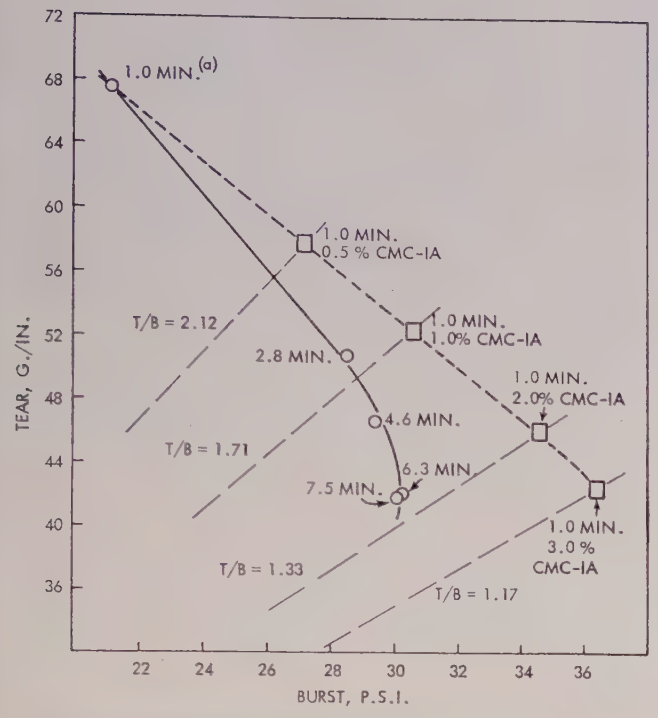

Fig. 4. Strength effects obtained with CMC-internal additive (40 lb. bleached sulfite handsheets)

(a) Beating Time in Min./Lb.

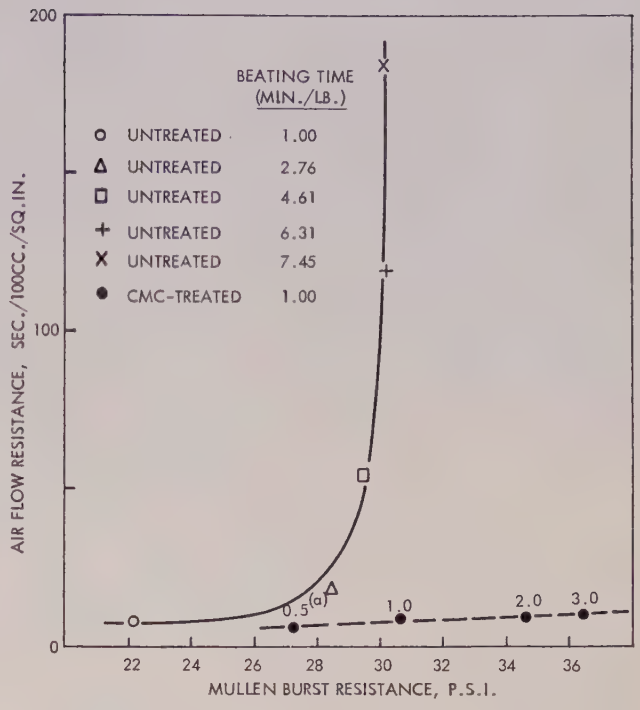

Fig. 5. Disproportionation of burst and air resistance with CMC-internal additive

(a) % CMC-IA Based on Pulp

resistance with increased beating of the untreated stock. With CMC-IA present, however (see broken line), increases in burst are accompanied by very small increases in air resistance. The result is a disproportionation of these two properties. The combinations of burst and air resistance values obtained by adding CMC-IA cannot be obtained by mechanical refining alone.

Other Handsheet Results

The property effects described above were obtained with bleached sulfite handsheets. Detailed data are given in Table I. Similar strength effects have been obtained with unbleached kraft handsheets both with and without alum and rosin size present. When 0.5% CMC-IA is used, the normal level of burst increase is 25 to 30% for rosin-sized handsheets and 20 to 25% for unsized handsheets. In an alum-free system, water hardness appears to play a role in CMC-IA retention. Using burst increase as an index of retention, it appears that retention increases as water hardness increases up to about 100 p.p.m.

Mill Results

The substantial strength effects described above can be consistently reproduced in handsheets. In the mill these improvements are not consistently obtained under all conditions and their measurement is often more difficult. Both the lower incidence of improvement and the greater difficulty of measurement are no doubt due in large part to the greater complexity and the less effective control of the mill papermaking system. Despite these difficulties, however, many mills are getting economically attractive results, several examples of which are shown in Tables IIa and IIb.

In Table IIa, example 1 shows a 16% increase in the burst resistance of an unsized container liner obtained by adding 3.5 lb. of CMC-IA per ton. In example 2, 4 lb. of CMC-IA has been used to replace 8 lb. of mannogalactan gum in kraft test liner at a 15% cost savings. Example 3, also on kraft test liner, shows that 3.5 lb. of CMC-IA was used to replace 5 lb. of mannogalactan gum and 5 lb. of starch. The result was an 8 to 10 point increase in burst, equivalent ring crush resistance, and a small (7%) cost savings.

Example 4 shows a 15% increase in the burst resistance of jute test liner resulting from the addition of 7 lb. of CMC-IA per ton. Another jute liner mill (example 5) used 2 lb. of CMC-IA and 30 lb. of starch in place of 60 lb. of starch for burst control at a 20% cost savings.

Examples 6, 7, 8, and 9 demonstrate the value of CMC-IA for improving the crush resistance of both kraft and bogus corrugating medium. Increases of 11 to 25% were obtained with 5 to 10 lb. of CMC-IA per ton. In one instance (ex-

Table I. CMC-Internal Additive-Handsheet Data[a]

Beating time, min./lb.	*S.-R. Freeness,*[b] *cc.*	*CMC-IA added, %*	*Mullen burst, p.s.i.*	*CMC-IA burst increase, %*	*Elmendorf tear, lb./in.*	*Tear/burst ratio*	*Net strength increase, %*	*Air resistance, sec.*
1.00	830	...	22.2	..	67.5	3.04	..	7
1.00	820	0.5	27.2	23	57.7	2.12	4	6
1.00	810	1.0	30.6	38	52.3	1.71	6	9
1.00	800	2.0	34.6	56	46.0	1.33	(18)[c]	9
1.00	790	3.0	36.4	64	42.4	1.17	..	10
2.76	745	..	28.5	..	50.7	1.78	..	18
4.61	640	..	29.4	..	46.5	1.58	..	54
6.31	540	..	30.2	..	42.0	1.39	..	119
7.45	455	..	30.1	..	41.9	1.39	..	185

[a] 40-lb. handsheets were made from bleached sulfite pulp beaten in a Noble and Wood Cycle Beater. CMC-IA and alum (to pH 4.5) were added after beating and at a stock consistency of 2.5%.
[b] Taken after addition of CMC-IA and alum.
[c] Approximate value.

Table IIa. Mill Data

Example no.	Grade of paper	CMC-IA, lb./ton	Property improvement, % Burst	CMT crush	Other
1	Container liner, unsized (cylinder)	3.5	16	..	.....
2	Kraft test liner (fourdrinier)	4	..	..	Ring crush equivalent to 8 lb. mannogalactan gum; 15% cost savings
3	Kraft test liner (fourdrinier)	3.5	..	..	Burst 8–10 points superior and ring crush equivalent to 5 lb. mannogalactan gum plus 5 lb. starch; 7% cost savings
4	Jute test liner	7	15	..	.....
5	Jute test liner	..	..	..	2 lb. CMC-IA and 30 lb. starch used in place of 60 lb. starch; 20% cost savings
6	Kraft corrugating (fourdrinier)	10	..	20	.....
7	Bogus corrugating (cylinder)	10	..	25	.....
8	Bogus corrugating (cylinder)	3.5	..	..	CMT crush equivalent to 8–9 lb. mannogalactan gum; 35% cost savings
9	Bogus corrugating (cylinder)	5	..	11	.....

ample 8), 3.5 lb. of CMC-IA was used to replace 8 to 9 lb. of mannogalactan gum at a cost savings of 35%.

In Table IIb, examples 1, 2, and 3 show burst increases and other effects on lighter weight sheets. CMC-IA was used to increase the burst and erasability of a manifold paper and to increase the burst and formation of an envelope stock (examples 1 and 2).

Example 3 of this group is of special interest. It involves the use of CMC-IA in a bleached sulfite paper containing a cationic wet-strength resin. The addition of 10 lb. of CMC-IA per ton produced a 23% increase in burst, a 100% increase in fold and a 67% increase in wet tensile, with no change in tear. Here we have an example of a net strength increase, i.e., an increase in one group of strength properties (e.g., burst) without the normal corresponding decrease in the opposing group of strength properties (e.g., tear). This net strength increase can be utilized either to produce a truly stronger sheet or to obtain the original strength at a lower basis weight or with a cheaper fiber furnish.

Actually, the CMC-IA appears to have served both as a dry strength additive and a wet-strength resin retention aid, and it is probable that the wet-strength resin has helped to produce the net increase in dry strength. The point of interest, however, is the evidence of a substantial fiber substitution value for the additives.

Examples 4 and 5 in Table IIb illustrate burst and surface pick improvements on white lined board.

SURFACE TREATMENT

Other types of CMC command an important place in the surface treatment of paper and paperboard. A range of viscosity types of Hercules CMC-7 (D.S. 0.7) are applied at the calender stack or size press to increase such properties as burst, wax pick, erasability, scuff resistance, oil holdout and air resistance, and to control curl.

Surface Treatment versus Internal Addition

In some respects the purpose and functional mechanism of surface treatment are the same as for internal addition. For example, both are used to increase burst, and in both the effect is achieved by increasing the extent of interfiber bonding.

The basic difference, productwise, between internal and surface treatment is in the vertical distribution of the additive in the sheet. With internal treatment, this distribution is presumably quite uniform and not easily changed. With surface treatment, the distribution may not be uniform and may be controlled, depending to some extent on the thickness of the sheet.

Control of Penetration

Control of depth of penetration in surface treatment is a useful tool. For the most efficient burst improvements, maximum penetration is desired; for the most efficient oil holdout, minimum penetration is the objective. The principal means of controlling penetration are solution viscosity (polymer D.P.), and chemical change at the instant the treating solution comes into contact with the paper. Within limits, solution penetration increases with decreasing solution viscosity. Thus, at a given dry add-on or cost of treatment, solution penetration may be varied by choice of polymer D.P. or viscosity type.

When maximum solution holding is desired, a second control factor may be used, i.e., thickening of the polymer solution at the instant of contact with the paper surface. The presence of aluminum ions in the paper can produce such an effect with CMC. For a given solution concentration, the magnitude of the effect increases with increasing D.P. and decreasing D.S. Thus, as a rule of thumb, maximum solution holdout is obtained by using the highest viscosity type and the lowest D.S. type which will meet the requirements of operable solution viscosity and good polymer solubility.

CMC-4 For High Holdout

Efficient surface treatment of milk carton board for wax holdout illustrates the importance of CMC solution holdout. A preferred type of CMC for this application is the newly developed Hercules CMC-4 (0.4 D.S.) of a medium to high viscosity type. Use of 1 part of Hercules CMC-4MHS

Table IIb. Mill Data

Example no.	Grade of paper	CMC-IA, lb./ton	Property improvement, % Burst	CMT Crush	Other
1	21-lb. manifold paper	7	13	..	>20% increased erasability
2	Unbl. envelope stock	8	12	..	Improved formation
3	40-lb. bl. sulfite with cationic wet-strength resin	10	23	..	100% increase in fold; 67% increase in wet tensile; no change in tear
4	White-lined board	3.5	10	..	.....
5	White-lined board	11 (Top Liner)	..	..	Wax pick increased from 14 to 18–20

with 5 parts of starch makes an excellent size press and calender box solution for treating milk carton board to control wax penetration. On the other hand, the recommended type of CMC for improving the burst resistance of printing or writing papers is Hercules CMC-7 of a low to medium viscosity type.

PIGMENT RETENTION

CMC is not only a dry-strength additive but also an effective pigment retention aid. Its greatest economic value as a retention aid is with titanium dioxide pigments. Cost savings are obtained by using 1 to 2% CMC based on the pigment. In most applications, a medium to high viscosity CMC-4 is preferred. The CMC may be added before, with, or after the pigment. Local conditions have a bearing on the most efficient amount of CMC and point of addition. CMC is especially effective as a pigment retention aid when oxidized starch is present in the papermaking system.

HANDLING CMC IN THE MILL

CMC is convenient to handle in the mill. Solutions are readily prepared in cold water and no cooking is required. When CMC is used with starch, the two materials may be added to water simultaneously and put through the usual starch cooking process. CMC solutions are resistant to spoilage, so there is normally no need to empty tanks and flush lines during shutdowns.

CMC-IA may be added to the stock as a solution at any convenient point from the beater to the fan pump. There may be a performance advantage in a certain point of addition in any given situation. CMC-IA may also be added dry at the beater. Dry addition should be followed by sufficient agitation to provide intimate and complete mixing of the CMC-IA with the stock.

SUMMARY

In conclusion, CMC is a versatile paper machine additive which can be applied either before or after sheet formation. Its utility lies in its similarity to cellulose and its polyelectrolyte, fiber-bonding, and film-forming properties. These latter properties are modified to fit each type of application by varying the D.S., D.P., and uniformity of substitution. For the most efficient results, care should be taken to select the preferred CMC for the specific need.

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Presented at the meeting of the Maine-New Hampshire Section of TAPPI, held in Portland, Me., Nov. 4–5, 1960.

RECENT BOOKS

Technical Communication. By George Harwell, Duke University. The Macmillan Co., New York, 1960. Cloth, 6 × 9, 332 pages. $5.00.

This textbook was written with the engineering student primarily in mind. It has three major motifs: an immediate and continuous effort to show what good writing really is; an approach that is consistent because it stresses underlying principles instead of a variety of surface practices; and models that are uniform in mechanics and uncomplicated in subject matter. Among the subjects covered are effective writing, organization of materials, methods of exposition, business letters, reports, technical articles, oral communication, illustrative material, and a manual of general composition.

Industrial Packaging. By Walter F. Friedman, Dasol Corp., and Jerome J. Kipnees, Atlantic Gummed Paper Corp., New York, 1960. John Wiley & Sons. Cloth, 6 × 536 pages. $11.50.

Packaging is currently one of the glamor topics in the field of marketing. Its importance as a selling medium has been widely recognized and its functional aspects have been made manifest at the many packaging and merchandising shows held around the country.

So important has the subject become several colleges and technical institutes have established instruction courses for the benefit of practitioners in the field and industrial designers. The present book is used as a text at the City College in New York where Mr. Kipnees lectures. Mr. Kipnees points out that there is a vast amount of data and other information available about packaging but as an instructor he was conscious of a real lack of interpretive material which is so important to management in formulating and executing packaging policy.

The authors offer much useful information on the field of corrugated and solid fiberboard, folding cartons and setup boxes, shipping sacks, nailed wooden boxes and crates, wire-bound and cleated containers, cylindrical shipping containers, wrappings, barriers and cushioning materials, fastenings and closures, packaging equipment and marking, labeling, and coding method, materials and equipment.

LETTERS TO THE EDITOR

Failure of Titanium in Dry Chlorine

To the Editor, *Tappi:*

If it is not too late to raise the matter again, we would like to reply to the letter from F. C. Hawks, Jr. which appeared in the August issue, reporting a failure of titanium in dry chlorine.

Several references have appeared in the literature in recent years to the fact that while titanium is completely resistant to wet chlorine gas, it is attacked, sometimes violently, by dry chlorine. In 1949 Hutchinson and Permar (*1*) reported that a violent exothermic reaction occurred with finely divided titanium exposed to nominally dry chlorine gas (0.005% water), but that the presence of water above 0.013% was apparently sufficient to render the titanium non-reactive. Stough, *et al.*, (*2*) found that the corrosion rate for unalloyed titanium exposed to water-saturated chlorine at 75°C. was less than 0.1 mils per year. In chlorine gas containing less than 0.1% water at 30°C. ignition occurred. In extensive corrosion studies in chemical plant exposure, Gegner and Wilson (*3*) reported ignition of massive titanium specimens in dry chlorine at temperatures down to minus 18°C. while in wet chlorine gas up to 96°C. corrosion rates were never higher than 0.1 mils per year. The combined effect of chlorine and sulfuric acid was also reported by these workers and by Gleekman (*4*).

The above results have been confirmed in our own laboratories. Titanium should not be exposed to dry chlorine gas, such as cylinder chlorine or process gas which has been dried with sulfuric acid.

Although immunity has been reported with as little as 0.013% water present (*1*) a safe limit is probably 0.1% water. Experimental work is now going on in our own laboratories to determine the minimum safe content of water more exactly. No attack on titanium by chlorine gas saturated with water

(e.g., brine cell gas) has ever been reported to our knowledge and titanium can be safely recommended in place of Hastelloy C in such environments.

In the case of the rotometer float which failed, while it is perhaps not surprising that neither the instrument manufacturers nor the chlorine supplier were previously aware of the danger, the supplier of the titanium could undoubtedly have advised against this application had he been consulted beforehand on the intended use. Responsible suppliers will always advise on the suitability of their materials in different environments and it pays to take them into one's confidence when considering changes in materials of construction or new applications.

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(P1063-61)

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An international manufacturer of paper and paper products has several openings for chemists or chemical engineers to work in the fields of product development and quality control. Salary is open. All replies held confidential. Please forward complete résumé. Send to **P1064-61, Tappi, 360 Lexington Ave., New York 17, N. Y.**

Southern paper sales representative to call on southern paper mills for established chemical company. Reply giving education and background to **P1065-61, Tappi, 360 Lexington Ave., New York 17, N. Y.**

PAPER RESINS & COATINGS
IMMEDIATE OPENING FOR CUSTOMER TECHNICAL SERVICE

Monsanto ®

For college graduate with 3 to 5 years experience in the paper industry. Opportunity to participate in expansion of plastic and resin applications, and new polymer systems. Scope may include both field contacts and application oriented laboratory work.

Please send complete résumé, in confidence, to:
Mr. J. M. Kemp, Mgr. Professional Employment,
MONSANTO CHEMICAL CO.,
Plastics Division, Springfield 2, Mass.
(P1066-61)

SUPERVISING ENGINEER
Pulp & Paper Mill Projects

Graduate engineer with exceptional pulp and paper mill experience and executive talents sought by leading equipment supplier and general contractor for complete pulp and paper mill projects.

This is a position of high responsibility offering creative opportunity for breaking new ground in the international pulp and paper industry.

Requires location in London and immediate attention to several projects now in progress.

Applicant must be qualified to organize internal engineering staff and supervise designing, specifications, and purchase of equipment for complete mill projects. Also supervise services of consulting engineers.

Solid mechanical and/or chemical background necessary and experience in contract negotiation. Moderate travel required. Knowledge of foreign languages desirable but not essential.

Please submit full résumé including salary expectations. Replies held in strict confidence.

Parsons & Whittemore/Lyddon Organization
250 Park Avenue
Room 1000-2
New York 17, N. Y.

(P1067-61)

CHEMIST

For integrated boxboard mill—carton plant operation—located in Illinois. Some knowledge of these industries desirable. Apply in writing stating educational background, experience and salary desired to **P1068-61, Tappi, 360 Lexington Ave., New York 17, N. Y.**

RESEARCH AND DEVELOPMENT

Immediate position open in Research and Development Department of absorbent specialty mill located in midwest. Prefer man with degree in chemistry and three years of paper mill experience. Knowledge of saturating papers and saturating resins desirable. Write to **P1069-61, Tappi, 360 Lexington Ave., New York 17, N. Y.**

RESEARCH AND DEVELOPMENT MANAGER

Large integrated and diversified pulp, paper and converted product manufacturer with a fine reputation for technical excellence is forming a Central Research and Development group. This group will serve all divisions. It will be located in the New York metropolitan area.

We are looking for a man capable of organizing, staffing and leading this group. He will report to the Corporate Director of Research and Development. Among the desired requirements would be:

1. Advanced degree.
2. Five to ten years industrial research and development experience, preferably in paper or related activities.
3. Some supervisory experience and ability.
4. Ability to formulate, organize, and carry through projects to successful completion.

If you have a strong desire to advance in this field and to take hold of an opportunity to build and lead an outstanding applied research and development organization, we would be happy to meet with you.

A man whose present position does not offer a challenge equivalent to his abilities and ambitions may find this an outstanding opportunity.

Salary will be commensurate with qualifications and experience.

Please submit résumé to **P1070-61, Tappi, 360 Lexington Ave., New York 17, N. Y.**

PLANT SUPERINTENDENT

Mid-western company seeking an experienced plant superintendent. This is an unusual opportunity for an alert, aggressive man who has demonstrated the leadership which would be required in establishing a new operation and growing with it.

Man selected must have the following qualifications:

Experience in supervising a machine operation, preferably machines which manufacture a variety of throw-away paper and paper board items. Experience in handling printing-flexograph and gravure.

Knowledge of paper.

Company offers exceptional benefit program. Please send résumé, recent photo, salary requirements to P1071-61, Tappi, 360 Lexington Ave., New York 17, N. Y.

Are you interested in

research?

Something pretty interesting is going on, research-wise, at Beloit Iron Works, Beloit, Wisconsin, where some of the world's largest paper machines are made. A new Research and Development Center, nearly completed, will provide 4,500 square feet of modern facilities for "paper research" by this internationally known company (est. 1858). If you are an engineer with a Bachelor's, Master's, or Doctor's degree and interested in research, look into this! Your specific areas of interest may cover pulp and paper, heat transfer, electronics and instrumentation, fluid mechanics, and mechanics. The man to query is Jerry Gannon, Employment Manager, Dept. A, Beloit Iron Works, Beloit, Wisconsin. **(P1072-61)**

STOCK PREPARATION

A multi-unit Canadian Organization requires experienced Stock Preparation Foreman for Paper Mill located in South America involved in the production of sanitary tissue papers.

Candidates must have a minimum of five years experience and a proven record of ability to produce furnishes for various grades of tissue and similar papers made on Fourdrinier—Yankee machines from combinations of virgin and secondary fibers.

Knowledge of English and/or Spanish desirable.

A generous salary, low income tax and other interesting considerations make these openings well worth exploring.

Address replies giving full particulars as to age, marital status, salary requirements, experience, etc. to:

Personnel Department
Box 659
Montreal, Quebec
Canada **(P1073-61)**

PROCESS AND QUALITY CONTROL

Quality Engineer: B.S. for statistical quality control, process capability, experimental design, vender liaison. About 4 years experience.

Process Engineer: B.S. in Pulp and Paper or Ch.E. for studies in lab and mill. 1 or 2 years experience.

Positions in Divisional Manufacturing Standards group of leading multi-plant manufacturer. Location in southern New England. All replies acknowledged.

P1074-61, Tappi, 360 Lexington Ave., New York 17, N. Y.

MACHINE ADJUSTER

Large company establishing a new mid-western operation. Unusually fine opportunity for a man to be in start of an entirely new venture with the security of a long established company. Must have experience in manufacture of a variety of throw-away paper and paper board items. Needs to be a good machinist, preferably someone with some knowledge of mechanical engineering and capable of simple revisions and of building attachments to existing machines. Company offers extraordinary paid benefits. Send résumé, recent photo to **P1077-61, Tappi, 360 Lexington Ave., New York 17, N. Y.**

CHEMIST or CHEMICAL ENGINEER WANTED

Graduate, with three to five years' experience in the pulp and paper industry, for an integrated bleach kraft pulp and specialty paper mill. Involves work in mill control and/or process control and development. Opportunity for a competent and ambitious man to advance to positions of greater responsibility. Excellent benefits and good starting salary. Please furnish complete particulars as to experience, education and reference to **P1075-61, Tappi, 360 Lexington Ave., New York 17, N. Y.**

PRODUCT DEVELOPMENT MANAGER— FOLDING CARTON

Folding carton division of a large multi-plant pulp, paper, and board manufacturer, is looking for a man to head up developmental activities concerned with carton functional design and construction, modification of board for functional uses, plastic combinations, and coordination of parallel packaging machinery development with carton and board development.

Among the desired requirements would be

1. Technical background in the carton field.
2. Some supervisory experience and ability.
3. Knowledge of board and plastics.
4. Some mechanical aptitude and know-how.
5. Some packaging background.

Salary will commensurate with qualifications and experience.
This is an opportunity to participate in, and help lead the growth of functional carton packaging with a large progressing company.
If you are interested send résumé to: **P1076-61, Tappi, 360 Lexington Ave., New York 17, N. Y.**

CHEMISTS PAPER CHEMISTS CHEMICAL ENGINEERS

The Mead Corporation has challenging staff positions in its expanding Central Research and Development Laboratories for experienced men for positions in the areas of:

1. Specialty papers—physical chemistry interest with paper-making experience
2. Paper Technology—improvement of the physical properties of paper including wet end studies
3. Basic Research—chemical modifications of pulp background in Polymer chemistry highly desirable
4. Coating—for both lab and mill
5. Pulping and Bleaching—Fundamental and applied research in stock preparation

We offer the opportunity for recognition and growth with friendly working and living conditions. Chillicothe, a town of about 28,000 is less than an hour's drive to Columbus.
Your résumé for these or other available positions, will receive immediate, confidential attention.

For more information, call collect or write to:

Mr. H. C. Meilinger
Employment Supervisor
The Mead Corporation
Chillicothe, Ohio

(P1078-61)

UNITED STATES PATENTS ON PAPERMAKING

Third Quarter, 1960 — *Compiled by The Institute of Paper Chemistry*

THE following list of United States patents has been compiled from the current numbers of the Official Gazette of the United States Patent Office. Because, as a rule, only one claim is published in the gazette, it is not claimed that the list is complete; also, it is possible that the list may contain some patents that do not apply specifically to pulp and paper manufacture. Copies of any of the following patents may be obtained from the United States Patent Office, Washington 25, D. C., by sending twenty-five cents for each patent desired. Or, those desiring the patents on *microcards* should write to The Institute of Paper Chemistry, Appleton, Wis.

July 5, 1960

Allen, Edward M. Paper pigments. U. S. pat. 2,943,970. Filed April 14, 1959. 34 claims. Assigned to Columbia-Southern Chem. Corp. [Cl. 162-181.] A siliceous paper-filling pigment is provided for improving the opacity and brightness of paper.

Allen, Edward M. Silica composition and production thereof. U. S. pat. 2,943,948. Filed June 24, 1959. 8 claims. Assigned to Columbia-Southern Chem. Corp. [Cl. 106-288.] A silica pigment of use as a paper filler is produced.

Arnold, Donald L. Dispenser package. U. S. pat. 2,944,124. Filed Oct. 16, 1969. 9 claims. Assigned to Sylvania Elec. Prods. Inc. [Cl. 206-56.] A carton for dispensing articles is provided with a follower device for urging the articles to the dispensing position.

Barrett, Neilon, and Grant, Chester A. Apparatus for use in assembling and applying book covers. U. S. pat. 2,943,336. Filed June 15, 1959. 7 claims. Assigned to Gaylord Bros., Inc. [Cl. 11-1.]

Barker, Alvin. Greeting card or folder. U. S. pat. 2,943,416. Filed March 19, 1958. 5 claims. [Cl. 46-34.] A greeting card has a spinning element.

Bolding, Hubert V. Recessed automatic bottom carton. U. S. pat. 2,943,780. Filed Feb. 26, 1958. (Divided; original filed March 23, 1955.) 3 claims. Assigned to Standard Pkg. Corp. [Cl. 229-39.]

Brown, Alfred D. Protective packaging. U. S. pat. 2,943,731. Filed Oct. 1, 1959. 14 claims. Assigned to Fellowcraft Eng., Inc. [Cl. 206-46.] Two nylon elements are employed to support a fragile article in slinglike fashion within a carton.

Bub, Robert A. Zigzag filter blank and method of making a filter. U. S. pat. 2,943,700. Filed April 27, 1959. 2 claims. Assigned to Mine Safety Appliances Co. [Cl. 183-71.]

Buttery, Kenneth T. Dispensing carton. U. S. pat. 2,943,779. Filed Dec. 23, 1957. 6 claims. Assigned to KVP Sutherland Paper Co. [Cl. 229-17.] A reclosable dispensing opening is formed at one upper corner of a carton for heavy materials.

Clark, Ralph H. Method of making duplicating transfer sheet and resultant article. U. S. pat. 2,943,952. Filed Dec. 14, 1956. 4 claims. Assigned to Burroughs Corp. [Cl. 117-36.] Long-lasting carbon paper is produced.

Dvoracek, Frank. Combination towel and wrap dispenser. U. S. pat. 2,943,777. Filed Feb. 20, 1959. 6 claims. Assigned to Burroughs Mfg. Corp. [Cl. 225-38.] A wall-mounted device is designed to support two rolls for dispensing, one of toweling and the other of wrapping material.

Erickson, Harold E., Riley, Robert W., and Schubert, Dale L. Felting apparatus. U. S. pat. 2,943,365. Filed Dec. 3, 1956. 11 claims. Assigned to Ind. Devt. Co. [Cl. 19-155.] Lignocellulosic particles are formed into mats for pressing into board.

Fasoli, Paul A. Paper making apparatus. U. S. pat. 2,943,678. Filed May 17, 1957. 4 claims. Assigned to Sandy Hill Iron & Brass Works. [Cl. 162-321.] Various improvements are made in a cylinder machine.

Fisher, John V., and Fisher, Constance M. Method of forming a carton. U. S. pat. 2,943,427. Filed Sept. 9, 1954. 2 claims. [Cl. 53-29.] A six-pack can carton is provided.

Foltz, Thomas R., Jr. Papermaker's felt. U. S. pat. 2,943,379. Filed May 23, 1958. 7 claims. Assigned to Lockport Felt Co., Inc. [Cl. 28-79.]

Freeman, Arnold B., Raffel, Bernard D., and Tripp, Roland A. Method of manufacturing fibrous material slab. U. S. pat. 2,943,968. Filed Nov. 20, 1956. 1 claim. Assigned to Goodyear Aircraft Corp. [Cl. 154-90.] A fiber-reinforced resin-bonded board is formed.

Goodrich, John J. Multiwall bag tear strips. U. S. pat. 2,943,781. Filed May 1, 1956. 4 claims. Assigned to St. Regis Paper Co. [Cl. 229-66.]

Harris, Thomas. Containers. U. S. pat. 2,943,758. Filed Aug. 19, 1958. 9 claims. Assigned to Structural Fibers, Inc. [Cl. 220-4.] Panels of resin-impregnated fiber are assembled to form a shipping and storage container for fragile articles.

Hawtin, Selwyn G., Parker, David R., and Downing, John. Manufacture of artificial materials. U. S. pat. 2,943,946. Filed Sept. 10, 1958. 10 claims. Assigned to British Celanese, Ltd. [Cl. 106-196.] The gel content in a solution of cellulose acetate is reduced.

Hindle, Thomas. Stretching machine for dryer felts and the like. U. S. pat. 2,943,375. Filed May 23, 1956. 8 claims. Assigned to Scapa Dryers Ind. [Cl. 26-68.]

Kovaleski, Joseph J., and Lewis, Thomas E., Jr. Package and container forming part thereof. U. S. pat. 2,943,732. Filed April 9, 1956. 2 claims. Assigned to Coulter & McKenzie Machine Co., Inc. [Cl. 206-59.] A paperboard core element is provided for insertion into a carton so that wire may be coiled about the core within the carton.

Leek, Francis W. J. Paper making and the like machines. U. S. pat. 2,943,677. Filed March 3, 1958. 20 claims. [Cl. 162-319.] A continuous wire, rather than a cylinder, is passed through a stock vat to form the web.

Leno, John A., and Searle, Arthur M. Printed electrical circuits. U. S. pat. 2,943,966. Filed Dec. 10, 1954. 1 claim. Assigned to Intern. Standard Elec. Corp. [Cl. 154-80.] Resin-impregnated paper is used.

McBain, John K. Method of making a spirally wound container. U. S. pat. 2,943,540. Filed Jan. 24, 1958. 14 claims. Assigned to W. C. Ritchie & Co. [Cl. 93-94.] A spirally wound container is formed from strips of paper and a transparent film, so that the finished container has window areas.

Meister, Albert A. Paper slipper. U. S. pat. 2,943,403. Filed Oct. 11, 1956. 2 claims. Assigned to Bagcraft Corp. of Am. [Cl. 36-9.]

Paulsen, Henry A. Depository calendar. U. S. pat. 2,943,778. Filed July 27, 1959. 6 claims. Assigned to Brown & Bigelow. [Cl. 229-8.5.] Coins may be inserted through slots in the calender face into an envelope attached behind the calender.

Phelps, Richard W. Paper machinery. U. S. pat. 2,943,806. Filed July 5, 1956. 9 claims. Assigned to Black Clawson Co. [Cl. 242-56.] A continuous web winder is designed so that the several steps involved in the winding of the web are carried out automatically in proper sequence.

Richardson, James A. Cartons. U. S. pat. 2,943,762. Filed Feb. 18, 1958. 12 claims. Assigned to Unipak Cartons, Ltd. [Cl. 220-105.] A bottle carton or the like is provided with a reinforcing and partitioning element.

Richardson, James A. Cartons. U. S. pat. 2,943,763. Filed Feb. 18, 1958. 8 claims. Assigned to Unipak Cartons Ltd. [Cl. 220-115.] A totally enclosed six-pack bottle carrier is provided with an integrally formed partitioning element.

Robinson, James V., and Shaffer, Ivan E. Casting surface for producing cast-surface mineral coating paper. U. S. pat. 2,943,954. Filed Feb. 10, 1958. 6 claims. Assigned to Mead Corp. [Cl. 117-64.]

Spechler, Daniel S. Cartographic material. U. S. pat. 2,943,936. Filed Dec. 13, 1956. 3 claims. Assigned to Keuffel & Esser Co. [Cl. 96-75.] Various cellulose derivatives are used in coating a base sheet to form a cartographic material.

Storage, Alexander E. Insulating board construction. U. S. pat. 2,943,965. Filed March 3, 1955. 1 claim. [Cl. 154-45.] A paperboard and aluminum foil structure is provided for installation between studs in building construction.

Stroop, John H. High speed packaging machine. U. S. pat. 2,943,428. Filed Nov. 1, 1956. 6 claims. Assigned to Vol-Pak, Inc. [Cl. 53-59.] Pharmaceutical tablets are sealed between webs of packaging material.

Taylor, Louis B. Pigmented paper and preparation thereof. U. S. pat. 2,943,971. Filed July 31, 1959. 13 claims. Assigned

to Columbia-Southern Chem. Corp. [Cl. 162-181.] Paper is filled with titanium dioxide and calcium silicate.

Tench, John D., and Duling, Irl N. Wax composition comprising a mixture of specific paraffin waxes and 1–2% of a microcrystalline wax. U. S. pat. 2,943,991. Filed March 13, 1958. 1 claim. Assigned to Sun Oil Co. [Cl. 208-21.] The wax is for coating food cartons.

Thumim, Carl. Crank drive for paper cutter knives. U. S. pat. 2,943,506. Filed May 24, 1957. 2 claims. Assigned to E. P. Lawson Co., Inc. [Cl. 74-414.]

Van Vactor, Alburtus O., and Lash, Eugene C. Loading device for a packaging machine. U. S. pat. 2,943,429. Filed July 29, 1959. 9 claims. [Cl. 53-182.] Wiping towels or cloths are fed to a machine for forming a bag about them.

Wachter, Aaron, and Wieland, Rita. Corrosion- and fungus-inhibiting composition. U. S. pat. 2,943,909. Filing Aug. 26, 1957. 6 claims. Assigned to Shell Oil Co. [Cl. 21-2.7.] VPI paper is prepared.

Wakeman, Arthur G. Pulpwood-debarking drum having angularly slotted wall and stationary shearing bars. U. S. pat. 2,943,656. Filed Aug. 24, 1956. 13 claims. Assigned to Coosa River News Print Co. [Cl. 144-208.]

Wrob, Ronald M., Carlson, Drexel T., and Stephens, Frederick N. Embossing apparatus. U. S. pat. 2,943,560. Filed Nov. 19, 1958. 8 claims. Assigned to Hallmark Cards, Inc. [Cl. 101-23.] An apparatus is provided for embossing a paper web being passed to an envelope-making machine.

July 12, 1960

Arneson, Edwin L. Container. U. S. pat. 2,944,719. Filed Aug. 8, 1956. 3 claims. Assigned to Federal Paper Board Co., Inc. [Cl. 229-31.] A greaseproof foil-lined carton has a corner construction which renders it liquidproof.

Bach, John W., Peet, Robert L., Jr., and Miller, Harry F. Letter flap moistener. U. S. pat. 2,944,511. Filed April 21, 1958. 10 claims. Assigned to Pitney-Bowes, Inc. [Cl. 118-243.]

Barton, Daniel M., Schoeffel, Eugene W., and Zimmermann, Frederick J. Process and apparatus for complete liquid-vapor phase oxidation and high enthalpy vapor production. U. S. pat. 2,944,396. Filed Feb. 9, 1955. 8 claims. Assigned to Sterling Drug Inc. [Cl. 60-39.05.] The condensable vapors from the Zimmermann wet combustion process are superheated.

Beach, Frank A. Detachable and foldable container carrier. U. S. pat. 2,944,713. Filed Oct. 7, 1957. 3 claims. [Cl. 224-45.] A carton with finger-holes in the end panels is provided with a handle element which engages the holes and reaches across the top of the case.

Boggs, Lawrence A., and Wiley, Averill J. Treatment of spent sulphite liquor. U. S. pat. 2,944,922. Filed April 23, 1956. 9 claims. Assigned to Sulphite Prods. Corp. [Cl. 127-37.] Sugars and ligneous materials are separately recovered.

Bourbeau, Francis J., Greenhalgh, John, and Valle, Claude F., Jr. Methods for treating polymeric plastic surfaces. U. S. pat. 2,944,294. Filed July 1, 1957. 4 claims. Assigned to Polaroid Corp. [Cl. 18-56.] Baryta paper coated with cellulose acetate is prepared for photographic use.

Bronson, Arthur H. Powdered composition consisting essentially of pentachlorophenol and a member of the group of metal naphthenates and mahogany sulfonates. U. S. pat. 2,944,936. Filed June 25, 1954. 7 claims. Assigned to Richfield Oil Corp. [Cl. 167-31.] The composition protects cellulosic materials against fungi and insects.

Bunge, Fred H., and Pocrnich, Ivan G. Ore beneficiation. U. S. pat. 2,944,666. Filed April 4, 1956. 13 claims. Assigned to M. A. Hanna Co. [Cl. 209-5.] Tall oil is used in a froth flotation process.

Bush, Arthur B., Jr., and Weil, Alice C. Fiberboard. U. S. pat. 2,944,930. Filed April 16, 1957. 10 claims. Assigned to Celotex Corp. [Cl. 162-145.] The reaction product of protein and sodium bentonite is used together with mineral and cellulose fibers to form an incombustible insulation board.

Choate, James R. Paperboard berry box. U. S. pat. 2,944,721. Filed Aug. 2, 1957. 1 claim. Assigned to Riverside Mfg. Co., Inc. [Cl. 229-34.] The box is increased in strength by providing an integral rim at the open edge of the box.

Christiansen, Robert J., Nevsimal, Rudolph J., and Volkert, Harold F. Automatic stitcher trimmer. U. S. pat. 2,944,456. Filed Dec. 5, 1957. 25 claims. Assigned to F. N. Volkert & Co. [Cl. 83-151.] Printed signatures are processed.

Commerford, John D., and Scallet, Barrett L. Starch dextrins and method of making same. U. S. pat. 2,944,913. Filed Nov. 17, 1958. 6 claims. Assigned to Anheuser-Busch, Inc. [Cl. 106-213.] A nonretrograding adhesive for paperboard is formed.

Dahlhauser, Anthony H., and Yaeger, Adolph H. Crate stacker. U. S. pat. 2,944,722. Filed June 9, 1958. 2 claims. Assigned to Keystone Steel & Wire Co. [Cl. 229-34.] Open-top produce cartons are provided with wire elements on the end walls which permit proper stacking of the cartons.

Doetsch, Wilhelm. Method and apparatus for the production of envelopes with gummed closing flaps. U. S. pat. 2,944,470. Filed May 6, 1958. 2 claims. [Cl. 93-62.]

Evans, Lyle W. Processing of image display devices. U. S. pat. 2,944,916. Filed Sept. 26, 1957. 2 claims. Assigned to Sylvania Elec. Prods. Inc [Cl. 117-33.5.] Cellulose nitrate is used in formulating a cathode ray tube screen coating.

Fish, Marion F. Hydraulic log barkers. U. S. pat. 2,944,741. Filed Feb. 25, 1957. 2 claims. Assigned to Summer Iron Works, Inc. [Cl. 239-184.] The hydraulic nozzle is directionally controlled.

Hayes, Edmund W. Pie shield. U. S. pat. 2,944,725. Filed July 16, 1958. 6 claims. [Cl. 229-34.] A paperboard blank attaches to the rim of a pie pan to keep the pan and pie properly spaced from an enclosing carton.

Heinzer, Hans. Machines for the production of bags consisting at least on their inside of thermoplastic material. U. S. pat. 2,944,469. Filed Dec. 11, 1957. 4 claims. Assigned to Schweizerische Industrie-Gesellschaft. [Cl. 93-8.]

Hoogstoel, Leon E. Packaging device. U. S. pat. 2, 944,716. Filed Sept. 17, 1958. 6 claims. Assigned to Norton Co. [Cl. 229-14.] Small articles are adhered to the adhesive surfaces of paper strips applied across a corrugated backing sheet.

Kibrick, Andre C., Scopp, Irwin W., and Colton, Raymond R. Method of preparing paper pulp. U. S. pat. 2,944,928. Filed Sept. 20, 1957. 6 claims. Assigned to Kibrick and Scopp. [Cl. 162-32.] Improved pulp yields are achieved in the kraft process by using a cooking liquor containing predominantly sodium polysulfides.

Knapp, Samuel B., and Wethern, James D. Rapid soda process for pulping bagasse and other non-woody plant lignocellulose. U. S. pat. 2,944,929. Filed Jan. 5, 1959. 14 claims. Assigned to Hawaiian Devt. Co., Ltd. [Cl. 162-90.]

Lefief, Frank M., and Baker, Thomas R. Hinge cover folding boxes. U. S. pat. 2,944,724. Filed May 8, 1958. 4 claims. Assigned to Baljak Corp. [Cl. 229-36.] The carton is designed so that the end tuck flaps may be closed by automatic machinery.

Levkoff, David. Cartons. U. S. pat. 2,944,720. Filed Feb. 8, 1957. 3 claims. Assigned 1/4 to Evelyn S. Levkoff, 1/4 to Henry S. Levkoff, and 1/4 to Edith L. Sennet. [Cl. 229-31.] A shock-resistant floating bottom construction is provided in a produce carton.

Lynch, Walton D. Tray package and method of making it. U. S. pat. 2,944,717. Filed Oct. 9, 1958. 3 claims. Assigned to Baljak Corp. [Cl. 229-23.] A carton is provided for enclosing a tray filled with frozen food.

McCauley, Wayne W. Flip-top package. U. S. pat. 2,944,726. Filed Feb. 11, 1958. 2 claims. [Cl. 229-44.] A flip-top closure is formed at one upper end of a carton for cigarettes, soap, etc.

Maier, Anton P. Dispenser for rolled paper. U. S. pat. 2,944,749. Filed Feb. 19, 1955. 2 claims. [Cl. 242-55.2.] A wall-mounted device is provided for dispensing sheets of toilet paper or toweling from a supply roll.

Marino, Joseph A., and Mayer, Louis. Interlocked carton. U. S. pat. 2,944,723. Filed July 14, 1958. 4 claims. Assigned to Owens-Illinois Glass Co. [Cl. 229-34.] An open-top carton is erected from a single blank by interlocking means.

Mitchell, James A., and Hinkle, Barton L. Process for the production of improved regenerated cellulose films. U. S. pat. 2,944, 296. Filed Feb. 2, 1956. 4 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 18-57.]

Moore, Norman H. Carton with snap-lock closure. U. S. pat. 2,944,727. Filed Jan. 28, 1957. 3 claims. Assigned to Fibreboard Paper Prods. Corp. [Cl. 229-45.]

Newcomb, Robert K. Laminating machines. U. S. pat. 2,944,587. Filed Feb. 10, 1958. 6 claims. Assigned to Rotobond. [Cl. 154-36.] Paper is laminated to plastic sheets without requiring heat to dissipate the solvents in the bonding material.

Obeck, Ferdinand J. Brush display card. U. S. pat. 2,944,665. Filed Jan. 31, 1957. 2 claims. Assigned to Pittsburgh Plate Glass Co. [Cl. 206-79.]

Odell, Robert C., Frentzel, Herman C., Scag, Dane T., and Netzler, John M. Capacitor pack winding machine. U. S. pat. 2,944,753. Filed April 9, 1958. 5 claims. Assigned to Allis-Chalmers Mfg. Co. [Cl. 242-67.3.] Foil and paper strips are wound into flattened capacitor form.

Peel, Clyde A., Peel, Richard O., and Peel, Donald G. Folding cigarette box with ash receptacle. U. S. pat. 2,944,555. Filed March 30, 1959. 15 claims. [Cl. 131-238.]

Prior, William L., and Snelson, Howard J. Process for steam treating magnesium cement fibrous panels. U. S. pat. 2,944,291. Filed Oct. 28, 1957. 13 claims. Assigned to Tectum Corp. [Cl. 18-47.5.]

Riehm, Theodor. Concentration of wood sugar solutions. U. S. pat. 2,944,923. Filed Jan. 17, 1958. 6 claims. Assigned to Udic Société Anonyme. [Cl. 127-37.]

Sage, Philip G. Garment hanger structure. U. S. pat. 2,944,711. Filed May 25, 1959. 4 claims. [Cl. 223-94.] A garment hanger is provided with a garment-supporting device made of paperboard which is adjustable to fit the shoulders of the garment.

Smith, John G. Document handling apparatus. U. S. pat. 2,944,913. Filed Nov. 13, 1958. 13 claims. Assigned to Burroughs Corp. [Cl. 271-71.] High-speed stacking and edge-alignment means are provided.

Stevenson, Betty F. Milk carton drip receptacle. U. S. pat. 2,944,700. Filed April 14, 1958. 4 claims. [Cl. 220-85.] A molded plastic device is provided to fit about the lower portion of a milk carton to receive drippings from the carton.

Storch, Henry H. Cigarette wrappers. U. S. pat. 2,944,553. Filed Sept. 27, 1954. 8 claims. Assigned to American Cyanamid Co. [Cl. 131-15.] Cigarette paper is replaced with a carbonyl-free polymer, such as polyethylene.

Stumpf, Howard, Jr. Shelf extender display or storage device. U. S. pat. 2,944,677. Filed June 3, 1959. 4 claims. Assigned to West Virginia Pulp and Paper Co. [Cl. 211-153.] The device is made of paperboard.

Thomasma, John C., and Thomasma, Charles W. Disposable seat covers. U. S. pat. 2,944,664. Filed Dec. 11, 1957. 16 claims. Assigned to Sanitor Mfg. Co. [Cl. 206-57.] A pack of disposable tissue paper toilet seat covers is provided.

Vergobbi, John G. Package. U. S. pat. 2,944,715. Filed Sept. 10, 1957. 1 claim. Assigned to Pneumatic Scale Corp., Ltd. [Cl. 229-14.] A lined carton is designed so that the liner may be completely closed and sealed in leakproof fashion.

Williamson, Marshall I. Multicellular folding boxes. U. S. pat. 2,944,718. Filed July 19, 1957. 7 claims. Assigned to Federal Paper Board Co., Inc. [Cl. 229-28.] A unitizing carton for cans is provided.

Winkler, Richard, and Dunnebier, Kurt. Method and apparatus for registering and timing envelope blanks and similar work pieces in the processing thereof. U. S. pat. 2,944,812. Filed May 31, 1957. 15 claims. Assigned to Berkley Machine Co. [Cl. 271-1.]

Wright, John G., Chafin, James M., and Wynn, George M. Wire package and support. U. S. pat. 2,944,758. Filed June 15, 1956. 3 claims. Assigned to Auto-Soler Co. [Cl. 242-129.] A carton containing a coil of wire is designed for use as a dispensing carton in a machine making wire fasteners.

Yang, Christen H. C. Sanitary paper and process of making the same. U. S. pat. 2,944,931. Filed Dec. 13, 1957. 10 claims. Assigned to Crown Zellerbach Corp. [Cl. 162-179.] Lanolin and a surfactant are added to a tissue paper furnish to improve softness.

Yanulis, Michael. Extrusion coating apparatus. U. S. pat. 2,944,586. Filed April 20, 1956. 8 claims. Assigned to Lowe Paper Co. [Cl. 154-1.] Polyethylene or the like is extrusion-laminated onto a paper web.

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Anderson, Arthur A., and Schuldt, Donald A. Circumferential tape applying. U. S. pat. 2,945,336. Filed April 4, 1957. 5 claims. Assigned to Minnesota Mining and Mfg. Co. [Cl. 53-198.] The machine provided forms a package of a number of produce items or the like by applying a band of tape about the items.

Cordell, Martin. Disposable filter bag. U. S. pat. 2,945,558. Filed Jan. 21, 1958. 3 claims. Assigned to Studley Paper Co., Inc. [Cl. 183-51.] An improved paper filter bag for a vacuum cleaner is provided.

Crawford, Thomas G., and Allen, John K. Composite laminated tube. U. S. pat. 2,945,638. Filed July 10, 1956. 3 claims. Assigned to Westinghouse Elec. Corp. [Cl. 242-118.32.] The tube, for textile pirns, etc., has inner layers of epoxide resin-impregnated glass and outer layers of phenolic resin-impregnated paper.

Dazzi, Joachim. Electrical devices. U. S. pat. 2,945,994. Filed Aug. 4, 1958. 4 claims. Assigned to Monsanto Chemical Co. [Cl. 317-258.] An insulation material comprises paper impregnated with furfuryl or tetrahydrofurfuryl chloro-substituted phenyl ethers.

Derrick, Robert P., and Campbell, Sylvester J. Paper mill winder drives. U. S. pat. 2,945,637. Filed July 19, 1957. 7 claims. Assigned to Westinghouse Elec. Corp. [Cl. 242-75.51.]

Harmon, Carlyle, and Shoemaker, Franklin W. Machine for and method of cross stretching nonwoven webs. U. S. pat. 2,945,283. Filed Oct. 30, 1956. 25 claims. Assigned to Chicopee Mfg. Corp. [Cl. 28-76.]

Honeyman, Robert B. Remover for rags and the like for a pulp treating machine. U. S. pat. 2,945,592. Filed Dec. 1, 1958. 4 claims. Assigned to Marden Machines Co. [Cl. 210-542.] A pulp shredder or slusher or the like is provided with means to remove rags, string, and other lightweight foreign materials.

Imhof, Alfred. High voltage insulator. U. S. pat. 2,945,912. Filed June 14, 1954. 11 claims. Assigned to Moser-Glaser & Co. A. G. [Cl. 174-30.] Part of the insulation is formed of oil-impregnated paper.

James, George M. Cellulosic sponge. U. S. pat. 2,945,772. Filed Jan. 24, 1958. 14 claims. Assigned to E. I. du Pont de Nemours & Co. [Cl. 117-98.] The life of the sponge is increased by impregnation with a rosin amine and a quaternary ammonium halide.

Johanningmeier, Charles E. Match book spinner. U. S. pat. 2,945,696. Filed May 13, 1959. 5 claims. [Cl. 273-147.] A matchbook may be converted to a spinning device for use in games, etc.

Kallmann, Heinz E. Talking book having magnetic recording means and shielding means therefor. U. S. pat. 2,945,307. Filed Oct. 31, 1955. 5 claims. [Cl. 35-35.]

Kelling, Leroy U. C. Intermittent feed cut-off register control. U. S. pat. 2,945,957. Filed April 21, 1958. 12 claims. Assigned to General Elec. Co. [Cl. 250-219.] A machine for cutting paper cup blanks from a preprinted web is provided with means to register and synchronize the web and die.

Lehman, Freeman R., Silvernail, Lloyd H., and Stilbert, Elmer K. Sizing of paper with acrylamide polymers. U. S. pat. 2,945,775. Filed April 18, 1955. 5 claims. Assigned to The Dow Chemical Co. [Cl. 117-155.]

McColl, Bruce J. Log transporting vehicle. U. S. pat. Re. 24,846. Filed Sept. 16, 1957. (Divided; original filed Oct. 18, 1955.) 9 claims. Assigned to Clark Equipment Co. [Cl. 214-77.] A self-propelled vehicle clamps chain binders about a pile of logs, then lifts and transports the pile.

Normandin, William O. Gusset type envelopes. U. S. pat. 2,945,616. Filed Nov. 23, 1956. 1 claim. Assigned to Canada Envelope Co. [Cl. 229-68.] The envelopes are constructed to be formed by automatic machinery.

Normandin, William O. Gusset type envelopes. U. S. pat. 2,945,617. Filed June 3, 1957. 2 claims. Assigned to Canada Envelope Co. [Cl. 229-68.] This is similar to U. S. pat. 2,945,-616 (July 19, 1960).

Perrault, Arthur. Machine for packaging soft printed butter. U. S. pat. 2,945,334. Filed Nov. 18, 1957. 40 claims. Assigned to Burch O. Gustafson, and Ralph L. Dugger. [Cl. 53-64.] Prints of butter are wrapped in parchment paper and cartoned.

Riehm, Theodor. Process for the saccharification of softwood sawdust. U. S. pat. 2,945,777. Filed Dec. 27, 1957. 1 claim. Assigned to Udic Société Anonyme. [Cl. 127-37.]

Swanson, Elmer C. Bag closure and opening device. U. S. pat. 2,945,615. Filed Oct. 28, 1957. 1 claim. [Cl. 229-66.] The stitched closure of a bag is provided with means for locking and for opening the stitching.

Touvay, Robert, and Martin, Philippe T. Method and apparatus for polishing. U. S. pat. 2,945,333. Filed June 2, 1950. 9 claims. Assigned to Société Anonyme des Mfrs. des Glaces et Produits Chimiques de Saint-Gobain. [Cl. 51-283.] Sawdust is used in a composition for polishing glass.

Waite, Fred L. Wrapping material web feeding mechanism. U. S. pat. 2,945,337. Filed Sept. 21, 1956. 12 claims. Assigned to American Machine & Foundry Co. [Cl. 53-389.] A web of wrapping material is intermittently supplied to a wrapping machine in accordance with the requirements of the machine.

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Bartus, Frank G. Combination toilet tissue roll and deodorant container. U. S. pat. 2,946,511. Filed May 26, 1958. 3 claims. [Cl. 239–52.]

Carew, Herman. Convertible cup dispensing mechanism. U. S. pat. 2,946,481. Filed Sept. 1, 1955. 4 claims. Assigned to American Can Co. [Cl. 221-222.] An apparatus is provided for dispensing cups singly from a nested stack of cups as in a vending machine.

Carter, Thomas N. Oscillator for web winding devices. U. S. pat. 2,946,532. Filed April 4, 1956. 10 claims. Assigned to The Champion Paper and Fibre Co. [Cl. 242-57.1.]

Clemens, Ludwig. Machine for the manufacture of packages for cut materials. U. S. pat. 2,946,167. Filed April 8, 1959. 16 claims. [Cl. 53-137.] The machine provided applies a wrapper to a stack of sheets of board, corrugated paper, or the like.

Collingwood, Merle J., and Chagnot, Albert C. Counting and displacing apparatus for printing press delivery mechanisms. U. S. pat. 2,946,266. Filed June 7, 1957. 6 claims. [Cl. 93-93.]

Convery, Sue J., and Convery, Rita. Educational test folder for teaching arithmetic. U. S. pat. 2,946,138. Filed Aug. 17, 1959. 6 claims. [Cl. 35-48.]

Cote, Omer E. Method of and machine for forming packages. U. S. pat. 2,946,165. Filed June 12, 1956. 15 claims. Assigned to U. S. Automatic Box Machinery Co., Inc. [Cl. 53-26.] The pack formed comprises 10 cereal packs in a flat tray with a transparent overwrap.

Coulter, James H., Jr., and Johnson, Lowell E. Chemical

and heat recovery apparatus. U. S. pat. 2,946,669. Filed June 10, 1957. 2 claims. Assigned to the Babcock & Wilcox Co. [Cl. 23-277.] An improved furnace for burning black liquor is provided.

Creelman, Edmund W. Hinge type carton. U. S. pat. 2,946,499. Filed July 10, 1958. 5 claims. Assigned to the C. W. Zumbiel Co. [Cl. 229-37.] A flat butter carton retains its form after opening and has a hinged cover which can be locked in closed position.

Davey, Charles B., and Wilde, Sergei A. Sawdust composts and method of preparing the same. U. S. pat. 2,946,675. Filed April 21, 1954. 3 claims. Assigned to Wisconsin Alumni Research Foundation. [Cl. 71-8.]

Farber, Jurgen. Stacking mechanism for receiving stacks of nested containers and individually delivering the same. U. S. pat. 2,946,480. Filed Aug. 17, 1956. 5 claims. Assigned to Jagenberg Werke Akt.-Ges. [Cl. 221-106.] The containers are conical paper containers.

Grassie, Vernon R. Manufacture of double-base propellant grains. U. S. pat. 2,946,673. Filed Dec. 29, 1955. 7 claims. Assigned to Hercules Powder Co. [Cl. 52-.5.] This is a method for processing cellulose nitrate.

Hennessey, Russell J. Display cartons. U. S. pat. 2,946,433. Filed July 11, 1958. 7 claims. Assigned to Waldorf Paper Prods. Co. [Cl. 206-45.19.] A tuck-end carton having an open display front is constructed for easy insertion of the article being packaged.

Hooper, William W., and Traver, George W. Merchandise rack and method of forming. U. S. pat. 2,946,500. Filed Oct. 29, 1958. 2 claims. [Cl. 229-42.] A partitioned paperboard element is provided for supporting cookies or the like in a form suitable for overwrapping.

Hornbostel, Lloyd. Paper machine drive mechanism. U. S. pat. 2,946, 231. Filed Sept. 26, 1955. 4 claims. Assigned to Beloit Iron Works. [Cl. 74-395.] Various sections of the line shaft operate at different speeds.

Hunger, James C., and Reed, George R. Folder cover. U. S. pat. 2,946,604. Filed July 15, 1957. 3 claims. [Cl. 281-34.] A paperboard file folder is provided with a removable protective cover device.

Johnson, Stanley R. Dispenser for article-containing envelopes. U. S. pat. 2,946,482. Filed July 2, 1957. 9 claims. [Cl. 221-240.] A mechanical device is provided for dispensing filled envelopes, such as band-aid type packages.

Kawasaki, Sozo. Process of making oil-impregnated machine parts from synthetic resin and the articles manufactured by said process. U. S. pat. 2,946,094. Filed June 11, 1956. 6 claims. [Cl. 18-47.5.] The parts are made of wood flour and a thermosetting resin.

Kuss, Ralph L. Container. U. S. pat. 2,946,494. Filed Oct. 3, 1958. 3 claims. Assigned to R. L. Kuss & Co., Inc. [Cl. 229-14.] A container for chemicals and other powders and liquids comprises a polyethylene bag in a paperboard box.

Lange, Ferdinand. Container device. U. S. pat. 2,946,495. Filed March 25, 1955. 1 claim. Assigned to Firma Werner Bahlsen. [Cl. 229-16.] A moistureproof odor-tight container for foods is formed from a single blank without wasting container-forming material.

Lowther, Thomas. Paper storage unit. U. S. pat. 2,946,635. Filed Oct. 25, 1957. 3 claims. [Cl. 312-39.] A cabinet supports and stores both rolls and sheets of sensitized paper for use in a photographic reproduction process.

Manwaring, Joshua G. D., and Cota, Raymond H. Method and apparatus for sealing metal foil. U. S. pat. 2,946,168. Filed Oct. 8, 1957. 13 claims. Assigned 50% to Radio Frequency Co., Inc. [Cl. 53-230.] Heat-sealing of a paper-foil sheet laminated with wax is effected.

Marti, Paul O. Gas generating composition containing surfactant. U. S. pat. 2,946,671. Filed April 26, 1955. 8 claims. Assigned to Standard Oil Co. [Cl. 52-.5.] Cellulose acetate is used in formulating a rocket or airplane propellant.

Metzger, Melvin R. Valve-equipped containers. U. S. pat. 2,946,502. Filed Nov. 10, 1954. 3 claims. [Cl. 229-62.5.] An improved check valve construction is provided in one face of a flat container formed of cellophane.

Meyers, Harold S. Package supports. U. S. pat. 2,946,455. Filed July 24, 1958. 5 claims. Assigned to Waldorf Paper Prods. Co. [Cl. 211-49.] A paperboard rack is provided for supporting packs of shingled bacon strips.

Muttera, William H., Jr. Transferring pressure sensitive mass. U. S. pat. 2,946,370. Filed May 22, 1957. 9 claims. Assigned to W. H. Brady Co. [Cl. 154-1.6.] A pressure-sensitive adhesive is transferred from a release-coated paper web onto aluminum labels or the like.

Penney, Ernest. Holder for toilet paper. U. S. pat. 2,946,636. Filed July 18, 1958. 13 claims. [Cl. 312-39.] A wall-mounted holder for bundles or rolls of toilet paper prevents pilfering of the bundle or roll.

Pityo, Albert F. Web feeding mechanism. U. S. pat. 2,946,586. Filed Sept. 17, 1953. 3 claims. [Cl. 271-2.4.] A web is fed in intermittent manner regardless of variations in speed or of lost motion in the drive.

Pityo, Albert F. Web feeding mechanism. U. S. pat. 2,946,588. Filed Jan. 3, 1958. 3 claims. [Cl. 271-2.4.] A web is fed in an intermittent manner without permitting moving or slipping of the web during nonfeeding intervals.

Poschman, William M., II. Safety match book holder. U. S. pat. 2,946, 432. Filed Nov. 25, 1958. 1 claim. [Cl. 206-33.]

Potts, William M., Hartis, William E., and Darholt, Jerome O. Method of placing cartons into packing cases. U. S. pat. 2,946,164. Filed May 3, 1955. 1 claim. Assigned to Dacam Corp. [Cl. 53-26.] Positive control over the cartons is maintained during the casing operation.

Randles, Arthur E., Jr. Carton. U. S. pat. 2,946,497. Filed May 14, 1957. 1 claim. Assigned 50% to Fred E. Helmick. [Cl. 229-28.] An egg carton is provided with improved stacking strength.

Ryno, Juddson B. Towel dispenser. U. S. pat. 2,946,587. Filed June 24, 1957. 3 claims. Assigned to Reliable Engineering Co. [Cl. 271-2.4.] A wall-mounted dispenser for paper toweling is provided.

Schladermundt, Peter, Denerlein, William H., and Simons, Langdon S., Jr. Adhesive bandage. U. S. pat. 2,946,435. Filed May 2, 1956. 15 claims. Assigned to Johnson & Johnson. [Cl. 206-63.2.] An envelope and bandage assembly is constructed to facilitate sanitary opening of the envelope and application of the bandage.

Sohn, Allen O. Apparatus for feeding, printing and cutting a strip into discrete printed portions. U. S. pat. 2,946,281. Filed Jan. 12, 1955. 18 claims. [Cl. 101-227.] These operations, conducted at a single station, produce labels.

Spiro, Murray, and Neimeth, George. Sheet feeding mechanism. U. S. pat. 2,946,589. Filed March 19, 1958. 14 claims. [Cl. 271-26.] A machine for stream-feeding sheets from a supply pile to a printing press is provided with means to engage and separate the top sheet of the supply pile.

Stagmeier, Arthur F. Carton. U. S. pat. 2,946,496. Filed April 16, 1957. 6 claims. Assigned to General Foods Corp. [Cl. 229-17.] An improved top closure is provided in a carton for comminuted foodstuffs.

Stephens, Joseph F., and Kerr, Glenn W. Method of making thermal pipe insulation. U. S. pat. 2,946,371. Filed July 24, 1956. (Divided; original filed Nov. 5, 1952.) 9 claims. Assigned to Gustin-Bacon Mfg. Co. [Cl. 154-28.] Glass fibers are air-laid, resin-impregnated, wrapped about a mandrel, cured, and slit from the mandrel.

Tachikawa, Shozo. Process for the manufacture of viscose rayon staple. U. S. pat. 2,946,650. Filed Feb. 17, 1958. 7 claims. Assigned to Tatsuji Tachikawa. [Cl. 18-54.]

Tachikawa, Shozo. Process for the manufacture of viscose rayon staple. U. S. pat. 2,946,782. Filed April 5, 1957. 4 claims. [Cl. 260-217.] The xanthating medium used contains carbon disulfide, Turkey red oil, and a monoamine; high D.P. rayon is made.

Väinö, Henrik. Cover for the suction box of paper making machines. U. S. pat. 2,946,379. Filed July 13, 1955. 4 claims. [Cl. 162-374.] The cover is formed of thin strips of wood veneer glued together in face-to-face relation.

Warner, Edgar. Apparatus for coating paper. U. S. pat. 2,946,307. Filed Dec. 23, 1955. 6 claims. Assigned to Champion Paper and Fibre Co. [Cl. 118-119.]

Williamson, Marshall I. Handle for multicellular folding boxes. U. S. pat. 2,946,501. Filed July 19, 1957. 9 claims. Assigned to Federal Paper Board Co., Inc. [Cl. 229-52.] A separate handle element is provided for a six-pack bottle carrier.

Williamson, Marshall I. Multicellular folding box structures. U. S. pat. 2,946,436. Filed July 19, 1957. 6 claims. Assigned to Federal Paper Board Co., Inc. [Cl. 206-65.] A unitizing pack for cans, jars, etc., comprises a paperboard sleeve having apertures in the top panel for insertion of the articles.

Williamson, Marshall I. Multicellular folding box structures. U. S. pat. 2,946,498. Filed July 19, 1957. 8 claims. Assigned to Federal Paper Board Co., Inc. [Cl. 229-28.] The carton is for packing fragile articles such as electric light bulbs.

Williamson, Marshall I. Single can carrier. U. S. pat. 2,946,620. Filed July 19, 1957. 7 claims. Assigned to Federal Paper Board Co., Inc. [Cl. 294-87.2.]

Williamson, Marshall I. Two can carrier. U. S. pat. 2,946,-621. Filed July 19, 1957. 5 claims. Assigned to Federal Paper Board Co., Inc. [Cl. 294-87.2.]

Worth, Sidney V., and Rebling, Robert C. Child's story book with shiftable pictures. U. S. pat. 2,946,137. Filed Aug. 10, 1959. 5 claims. [Cl. 35-35.]

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Asten, Dietrich V., and Schoepf, John G. Asbestos dryer felt. U. S. pat. 2,947,328. Filed May 10, 1955. 3 claims. Assigned to Asten-Hill Mfg. Co. [Cl. 139-412.]

Azari, Eric, Gray, Alfred E., Malin, Herman J., and Thomp-

son, Harold B. Card feeding apparatus. U. S. pat. 2,947,538. Filed Feb. 24, 1958. 18 claims. Assigned to the Magnavox Co. [Cl. 271-11.] The apparatus can be used whether to receive and stack the cards or to feed them to the machine.

Bailey, Berry W. Processing of spent cooking liquors. U. S. pat. 2,947,656. Filed April 15, 1957. 14 claims. Assigned to Scott Paper Co. [Cl. 162-32.] A process is provided for recovering chemicals from ammonia-base spent cooking liquors.

Baumann, Marie C. Carton insert. U. S. pat. 2,947,460. Filed Jan. 22, 1959. 5 claims. Assigned to Pet Milk Co. [Cl. 229-14.] An insert is provided to overlie the ends of small cartons within a shipping case so that the case may be slit open without damaging the cartons.

Bennett, Phillip. Loose leaf binders. U. S. pat. 2,947,309. Filed Dec. 17, 1957. 1 claim. [Cl. 129-24.]

Bostock, Raymond N. Carrier for bottles and the like. U. S. pat. 2,947,462. Filed Feb. 24, 1954. 9 claims. Assigned to P. Ballantine & Sons. [Cl. 229-23.] A bottle case includes a lightweight disposable outer case, an inner re-usable sling, and a re-usable partitioning element which fits into the sling.

Brötz, August, Richter, Kurt, Wachtendorf, Wilhelm, and Heuer, Kurt. Manufacture of viscose rayon. U. S. pat. 2,947,597. Filed Feb. 18, 1957. 4 claims. Assigned to Am. Enka Corp. [Cl. 18-54.] High-tenacity all-skin rayon is formed.

Caresio, Dominic J. Carton flap deflecting and separating means. U. S. pat. 2,947,229. Filed July 30, 1958. 3 claims. Assigned to Fibreboard Paper Prods. Corp. [Cl. 93-53.] The flaps of a collapsed box are separated in preparation for erecting the carton.

Carhuff, LeRoy F. Printing attachment for egg carton hand set-up machine. U. S. pat. 2,947,228. Filed Aug. 8, 1958. 7 claims. Assigned to Diamond Natl. Corp. [Cl. 93-37.]

Carter, Sidney T. Gum-applying apparatus for labeling machines. U. S. pat. 2,947,433. Filed Oct. 23, 1958. (Divided; original filed Dec. 5, 1955.) 11 claims. Assigned to Geo J. Meyer Mfg. Co. [Cl. 216-12.]

Chapman, Ralph. Method of manufacturing a composite broad product. U. S. pat. 2,947,654. Filed March 26, 1956. 5 claims. Assigned to Wood Processes (Oregon) Ltd. [Cl. 154-100.] The board comprises a core layer of adhesive-coated wood flakes faced with sheets formed by sheeting an aqueous slurry.

Conklin, Charles S. Closure lids for paper containers. U. S. pat. 2,947,463. Filed June 27, 1957. 7 claims. Assigned to Lily-Tulip Cup Corp. [Cl. 229-43.] An improved plastic closure disk is provided for a round paper container having a beaded edge.

Curtenius, Frederick B. Machine for stacking paper including oppositely withdrawable adjacent stack supports. U. S. pat. 2,947,428. Filed April 29, 1954. 12 claims. Assigned to Rice Barton Corp. [Cl. 214-6.]

Derenski, Francis W. Easel book structure. U. S. pat. 2,947,552. Filed Aug. 8, 1958. 2 claims. [Cl. 281-33.] Paperboard devices are secured within the cover of a book so that, when they are unfolded, they can support the book in easel fashion.

Eberhardt, Lee E. Method of producing wood pulp. U. S. pat. 2,947,655. Filed April 21, 1955. 13 claims. Assigned to The Bauer Bros. Co. [Cl. 162-26.] The method produces groundwood from chips.

Ennis, John L. Corrosion inhibitors. U. S. pat. 2,947,599. Filed July 5, 1955. 4 claims. Assigned to Arthur D. Little, Inc. [Cl. 21-2.5.] A corrosion-inhibiting wrapping comprises paper impregnated with an organic sulfide such as thiodiglycol diacetate.

Fenton, Frank W. Pattern-determining apparatus for pallet loader. U. S. pat. 2,947,405. Filed Dec. 31, 1956. 9 claims. Assigned to Beacon Production Equipment Corp. [Cl. 198-33.] The apparatus palletizes cartons according to a predetermined pattern.

Fobiano, Frank E. Sandwich package. U. S. pat. 2,947,637. Filed April 7, 1958. 4 claims. Assigned to Premier Carton Co. [Cl. 99-171.] A carton for sandwiches is designed to be opened to display the contents.

Frantz, Verne L. Pressure sensitive adhesive composition and tape coated therewith. U. S. pat. 2,947,810. Filed Nov. 15, 1955. 2 claims. Assigned to Johnson & Johnson. [Cl. 206-5.] The adhesive is flameproof and flame retardant.

Gaslini, Franco. Process for the hydrogenation of lignin and lignocellulosic materials. U. S. pat. 2,947,739. Filed June 9, 1958. 6 claims. [Cl. 260-134.]

Gerhardt, James S., and Fowler, William F., Jr. Adhesive. U. S. pat. 2,947,650. Filed June 13, 1958. 2 claims. Assigned to Eastman Kodak Co. [Cl. 117-122.] A pressure-sensitive adhesive for use in forming paper-backed tape is provided.

Goss, Herbert A. Log binder. U. S. pat. 2,947,514. Filed April 4, 1958. 4 claims. [Cl. 254-78.] A remote-release tensioning and clamping device for log load binding chains is provided.

Hart, John C., and Lauring, Edgar A. Fissured coated fiberboard and method of manufacture. U. S. pat. 2,947,647. Filed Sept. 24, 1958. 7 claims. Assigned to Minnesota and Ontario Paper Co. [Cl. 117-41.]

Herman, Philip. Package wrapping machine. U. S. pat. 2,947,127. Filed March 26, 1959. 13 claims. Assigned to Herman & Leal, Ltd. [Cl. 53-182.]

Hornbostel, Lloyd. Paper machine dandy roll construction. U. S. pat. 2,947,356. Filed March 11, 1957. 3 claims. Assigned to Beloit Iron Works. [Cl. 162-314.]

Johnson, Richard H. Shipping container with side closure. U. S. pat. 2,947,414. Filed April 25, 1958. 12 claims. Assigned to Container Corp. of Am. [Cl. 206-46.] The container is a large case for shipping refrigerators or the like.

Kasten, Walter. Filter and method of making. U. S. pat. 2,947,419. Filed May 26, 1955. 12 claims. Assigned to Bendix Aviation Corp. [Cl. 210-435.] A cylindrical filter element is formed of an inner nylon fiber element surrounded by an outer resin-impregnated paper element.

Konrad, Alexander. Dual flavor cigar or cigarette. U. S. pat. 2,947,310. Filed March 12, 1959. 1 claim. [Cl. 131-9.] A band of flavoring material is positioned within the paper wrapper of a cigarette—or within a cigar.

Kropa, Edward L. Animalization of cellulose. U. S. pat. 2,947,594. Filed Dec. 9, 1957. 12 claims. Assigned to American Cyanamid Co. [Cl. 8-117.] Cellulosic materials are rendered dyeable by certain acid dyestuffs by reaction with a vinyl quaternary ammonium compound.

Ladeuze, Maurice J. B., and Toni, Pierre. Process for the treatment of tracing papers to make them readily erasable upon. U. S. pat. 2,947,640. Field Sept. 2, 1958. 2 claims. [Cl. 106-2.]

Martin, Iliff H. Paper folding device. U. S. pat. 2,947,536. Filed June 3, 1957. 6 claims. [Cl. 270-79.] Strips of paper issued by business machines are folded into zigzag configuration.

Milne, David T. Stable cellulose ether compositions and method for producing the same. U. S. pat. 2,947,645. Filed Oct. 29, 1957. 10 claims. Assigned to American Viscose Corp. [Cl. 106-170.]

Newton, Donald O. Handle bags. U. S. pat. 2,947,464. Filed Oct. 22, 1957. 2 claims. Assigned to St. Regis Paper Co. [Cl. 229-54.] A paperboard element is stitched into the closure of a multi-ply bag for use as a handle.

Peteri, Robert. Extraction of cellulose from vegetable matter. U. S. pat. 2,947,657. Filed Feb. 15, 1957. 7 claims. Assigned to Compagnie de Saint-Gobain. [Cl. 162-76.] A bright sulfite or neutral sulfite pulp is produced by adding a hydrosulfite to the cooking liquor.

Polzella, Louis C., Snowdon, Arthur E., and Carpenter, William P. Transformer coil construction. U. S. pat. 2,947,959. Filed Nov. 28, 1955. 1 claim. Assigned to Superior Elec. Co. [Cl. 336-198.] A resin-coated paper is used to form protective pieces in the coil construction.

Pregent, Thomas W. Cushioning pad for packaged articles. U. S. pat. 2,947,459. Filed Sept. 25, 1958. 2 claims. Assigned to International Harvester Co. [Cl. 229-14.] A structure of coiled corrugated board is provided for use as an interior packing element within a carton.

Rogers, Charles H. Stabilized bordeaux mixture composition. U. S. pat. 2,947,659. Filed March 5, 1956. 7 claims. Assigned to R. T. Vanderbilt Co., Inc. [Cl. 167-16.] Lignosulfonates are used in forming an additive for stabilizing certain suspensions of matter.

Sonnabend, Lawrence F., and Williams, Charles R. Resinification of wood. U. S. pat. 2,947,648. Filed Dec. 21, 1955. 14 claims. Assigned to Dow Chemical Co. [Cl. 117-59.]

Tuomala, Leon A., and Borba, Lawrence J. Disposable cigarette case. U. S. pat. 2,947,413. Filed Nov. 12, 1957. 4 claims. [Cl. 206-41.1] A cigarette box of paperboard is constructed to have the appearance of a metal cigarette case of the type which opens like a book.

Weschler, Joseph R., and Engel, Edward W. Method of manufacturing unified paper containing titania. U. S. pat. 2,947,658. Filed July 10, 1956. 4 claims. Assigned to Johnson & Johnson. [Cl. 162-169.] The titania is added to the stock along with an elastomeric latex, then precipitated onto the fibers.

Wilson, Harry W., and Dornbush, Clinton L. Machine for packaging cartons. U. S. pat. 2,947,125. Filed April 29, 1957. 40 claims. Assigned to Royal Container Co. [Cl. 53-61.] Stacks of collapsed cartons are strapped to form a self-palletized bale.

Woodruff, Maurice D., and Textor, Clinton K. Disc refiner. U. S. pat. 2,947,485. Filed Feb. 5, 1954. 17 claims. Assigned to Bauer Bros. Co. [Cl. 241-32.]

Zenczak, Piotr. Method of producing, separating and recovering reaction products from bark. U. S. pat. 2,947,764. Filed Nov. 10, 1955. 2 claims. Assigned to Grenco, Inc. [Cl. 260-397.25.]

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Anderson, Andrew W. Mechanism for feeding and covering containers. U. S. pat. 2,948,096. Filed Oct. 31, 1958. 6 claims. Assigned to Scandia Packaging Machinery Co. [Cl. 53-287.] A sheet of metal foil is secured over the top of a container filled with food.

Arvidson, Bengt A. Web cutting mechanism. U. S. pat. 2,948,177. Filed May 29, 1956. 4 claims. Assigned to Miller Wrapping & Sealing Machine Co. [Cl. 83-155.]

Brown, Forrest A. Tissue dispenser for automobiles. U. S. pat. 2,948,574. Filed Feb. 8, 1956. 9 claims. [Cl. 312-39.]

Carkhiuff, Le Roy F. Expanding egg lifter. U. S. pat. 2,948,564. Filed Sept. 4, 1959. 15 claims. Assigned to Diamond Natl. Corp. [Cl. 294-87.] Eggs are transferred directly from packing case flats into egg cartons.

Copping, Bruce G. Box opening and dumping apparatus. U. S. pat. 2,948,425. Filed Oct. 11, 1956. 8 claims. Assigned to Atkron, Inc. [Cl. 214-311.] The machine provided opens and empties a case of cans, leaving the case in condition for reuse.

Corrin, Myron L. Method of impregnating mica paper with an alkyl orthotitanate, and product produced thereby. U. S. pat. 2,948,640. Filed Aug. 9, 1956. 6 claims. Assigned to General Elec. Co. [Cl. 117-119.]

Coventry, Henry J. Apparatus for cutting tacky material. U. S. pat. 2,948,328. Filed Nov. 7, 1957. 9 claims. Assigned to Western Elec. Co., Inc. [Cl. 154-1.] A method is provided for forming a package comprising waxed paper wrapped about an adhesive.

Cross, Carroll N. Method for fabricating mounts having display material. U. S. pat. 2,948,199. Filed Nov. 28, 1958. 4 claims. [Cl. 93-1.] A diecut paperboard sheet is diecut to form a mount for a thermometer.

De Villers, Edmund J., and Long, William J. Disposable type paper head dress. U. S. pat. 2,947,992. Filed Oct. 8, 1957. 1 claim. Assigned to Paperlynen Co. [Cl. 2-198.]

Doyle, William V. Molded pulp coated charcoal and charcoal briquettes. U. S. pat. 2,948,594. Filed Aug. 6, 1956. 25 claims. Assigned to Diamond Natl. Corp. [Cl. 44-6.]

Durant, Leonard G., and Surino, Alphonse. Continuous digester. U. S. pat. 2,948,336. Filed June 6, 1955. 1 claim. Assigned to Pandia, Inc. [Cl. 162-236.] A continuous digester is designed so that fibrous materials may be changed at more than one point, thus allowing materials requiring various pulping times to be pulped together.

Frankenstein, William P. Carton. U. S. pat. 2,948,455. Filed June 18, 1951. 9 claims. [Cl. 229-36.] The carton has an integral windowed cover and a platform intermediate between the cover and the bottom of the carton.

Gaines, George L., Jr., and Bueche, Arthur M. Mica paper. U. S. pat. 2,948,329. Filed Sept. 24, 1956. 3 claims. Assigned to General Elec. Co. [Cl. 154-2.6.] Mica paper with improved tensile strength and moisture resistance is obtained by impregnating the paper with an alkyl silicate and then hydrolyzing the silicate.

Gillmore, John E., Sr. Horizontal compartmentalized nursery box. U. S. pat. 2,948,454. Filed March 21, 1958. 3 claims. Assigned to Crown Zellerbach Corp. [Cl. 229-23.] A box for shipping potted plants is provided with a tray which forms an upper compartment in the box.

Grassie, Vernon R. Densification of nitrocellulose. U. S. pat. 2,948,601. Filed Nov. 17, 1958. 7 claims. Assigned to Hercules Powder Co. [Cl. 52-20.]

Grisetti, Charles V., and Langton, William J. Snap lock closure for a rectangular container. U. S. pat. 2,948,456. Filed Jan. 8, 1959. 2 claims. Assigned to Crown Zellerbach Corp. [Cl. 229-39.]

Jen, Yun, and House, Ronald R. Wet strength paper containing linear polyamide resin. U. S. pat. 2,948,652. Filed June 9, 1958. 8 claims. Assigned to American Cyanamid Co. [Cl. 162-166.]

Kyle, Colin. Method and apparatus for making hollow accreted fibrous bodies. U. S. pat. Re. 24,860. Filed Nov. 15, 1957. (Divided; original filed Nov. 15, 1955.) 11 claims. Assigned to Hawley Prods. Co. [Cl. 162-219.] A molded pulp article is initially formed in two parts which are felted together by a continuation of the accretion process.

McCluer, John D. Flame retarding composition and fabric treated therewith. U. S. pat. 2,948,641. Filed July 22, 1957. 11 claims. Assigned to Thermoid Co. [Cl. 117-126.] The composition includes a fluoroborate salt, mica, and a plasticizer.

McCollum, Melvin W. Tree harvesting apparatus. U. S. pat. 2,948,311. Filed Oct. 20, 1958. 4 claims. [Cl. 143-32.] A self-propelled machine is provided with chain saw means for delimbing felled or standing trees.

Mancuso, Joseph P., and Maffett, Robert R. Box forming machine. U. S. pat. 2,948,097. Filed Sept. 30, 1958. (Divided; original filed June 8, 1954.) 4 claims. Assigned to Robert E. Bauer. [Cl. 53-296.] A window-top carton is formed, filled with a pie, and sealed with a sheet of cellophane over the window.

Morrison, Willard L. Method of freezing foodstuffs and the like. U. S. pat. 2,948,123. Filed Aug. 20, 1957. 3 claims. Assigned to Liquefreeze Co., Inc. [Cl. 62-64.] A method is provided for freezing foods wrapped in paper by contacting with liquid nitrogen.

Price, Claude S. Method of coating a surface with a composition comprising a furfuryl alcohol resin, cellulose, filler, and catalyst. U. S. pat. 2,948,639. Filed May 15, 1958. 2 claims. [Cl. 117-104.]

Russell, Kenneth F. Box stacking mechanism. U. S. pat. 2,948,382. Filed Dec. 4, 1956. 21 claims. Assigned to Pomona Foundry, Inc. [Cl. 198-35.]

Scott, Harold E. B. Doctors for paper-making and other machines. U. S. pat. 2,948,012. Filed Dec. 14, 1956. 7 claims. Assigned to Vickerys, Ltd. [Cl. 15-256.5.] The blade is mounted in the holder so that dirt, fibers, etc. cannot get into the mounting recess.

Swanson, Frank R. Roll paper dispensing apparatus. U. S. pat. 2,948,451. Filed Sept. 26, 1957. 4 claims. [Cl. 225-38.] A wall-mounted cabinet is provided for dispensing several rolls of toweling, waxed paper, etc.

Thiele, Edward G. Bag for flour and the like. U. S. pat. 2,948,457. Filed Nov. 12, 1957. 4 claims. [Cl. 229-62.] A pouring spout closure is provided.

Wagaman, Merle L. Window carton. U. S. pat. 2,948,390. Filed June 23, 1959. 8 claims. Assigned to Fibreboard Paper Prods. Corp. [Cl. 206-45.31.] A window carton is constructed to have improved stacking strength.

Wells, Roger. Packaging. U. S. pat. 2,948,094. Filed Jan. 11, 1956. 32 claims. Assigned to Diamond Natl. Corp. [Cl. 53-37.] A web of waxed paper or the like is slit, rewound, and the smaller rolls are cartoned.

Wolter, Harry A. Pulp molding apparatus. U. S. pat. 2,948,337. Filed May 10, 1957. 13 claims. Assigned to Diamond Natl. Corp. [Cl. 162-392.] The apparatus has a single pair of pulp-molding dies.

Wolter, Harry A. Tray feeding apparatus. U. S. pat. 2,948,337. Field Dec. 27, 1957. 6 claims. Assigned to Diamond Natl. Corp. [Cl. 221-221.] Molded pulp trays are fed from the bottom of a supply stack, printed, filled, and sealed with a cover sheet.

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Abissi, Carl F. Perforating apparatus. U. S. pat. 2,949,292. Filed Oct. 29, 1957. 7 claims. Assigned to Intern. Business Machines Corp. [Cl. 269-160.] Scored portions of business machine cards are punched out.

Balkind, Solomon. Adjustable cigarette filter. U. S. pat. 2,949,116. Filed April 1, 1957. 1 claim. [Cl. 131-10.] The filter comprises a disk formed of absorbent paper and covered by cotton.

Beattie, Earl L. Rotary case printer. U. S. pat. 2,949,079. Filed Oct. 3, 1958. 1 claim. [Cl. 101-35.]

Bobst, Henri. Presses for treating material in the form of sheets. U. S. pat. 2,949,297. Filed April 3, 1957. 8 claims. Assigned to J. Bobst and Son S. A. [Cl. 271-45.] Chain conveyors for paper sheets, as used in a printing press, are provided with improved tensioning means.

Bolyard, Charles C. Sequin impregnated paper. U. S. pat. 2,949,398. Filed Nov. 22, 1955. 4 claims. [Cl. 162-181.]

Bonzagni, Francis A. Wet strength paper. U. S. pat. 2,949,-396. Filed May 23, 1956. 7 claims. Assigned to Monsanto Chemical Co. [Cl. 162-167.] The agent used is an acid-aged cationic sulfite-modified melamine-formaldehyde resin.

Brewer, Clarence T. Blank for truncated conical cups. U. S. pat. 2,949,216. Filed Sept. 30, 1958. 3 claims. Assigned to Dixie Cup Co. [Cl. 229-1.5.]

Busse, Curtis T. Machine for stacking cans on pallets. U. S. pat. 2,949,179. Filed March 21, 1958. 18 claims. Assigned 50% to Gilbert W. Busse. [Cl. 198-30.]

Cederquist, Karl Nicolaus. Continuous method of burning highly hydrous organic materials. U. S. pat. 2,949,010. Filed March 24, 1955. 15 claims. Assigned to Stora Kopparbergs bergslags AB. [Cl. 60-39.05.] A wet combustion method is provided for burning finely divided wood, sawdust, or peat.

Coe, Merrill J. Cartons and covers therefor. U. S. pat. 2,949,222. Filed April 2, 1959. 6 claims. Assigned to KVP Sutherland Paper Co. [Cl. 229-41.] A carton and separate cover is constructed to prevent contact of packaged articles with the walls of the carton.

De Woskin, Irvin S. Disposable absorbent pads. U. S. pat. 2,949,114. Filed Dec. 12, 1955. 3 claims. [Cl. 128-290.] An improved catamenial pad is produced.

Dickerman, Gilbert K., Kaulakis, Frank, and Savage, Richard L. Method of making printable coated paper. U. S. pat. 2,949,382. Filed Feb. 28, 1958. 5 claims. Assigned to Consolidated Water Power & Paper Co. [Cl. 117-65.]

Diesbach, Frederick B. Autographic register. U. S. pat. 2,949,318. Filed May 28, 1958. 1 claim. Assigned to Paul Benninghofen and F. B. Diesbach. [Cl. 282-3.] The register clamps and tensions the carbon paper of a manifold pack when the register lid is closed.

Draper, Ralph L., and Witzgall, Edward J. Magnetic separator. U. S. pat. 2,949,191. Filed Oct. 10, 1957. 9 claims. Assigned to John W. Bolton & Sons, Inc. [Cl. 210-222.] The separator may be cleaned while in operation.

Eichenlaub, George E. File and mail envelope. U. S. pat. 2,949,223. Filed Dec. 24, 1956. 2 claims. [Cl. 229-68.]

Fields, William L., and Cain, Clayborn Y. Signature feed device. U. S. pat. 2,949,293. Filed March 2, 1956. 8 claims. Assigned to R. R. Donnelley & Sons Co. [Cl. 270-56.]

Foote, Daniel J., and Berkowitz, Nathan L. Padlock display cards. U. S. pat. 2,949,185. Filed May 19, 1958. 2 claims. Assigned to Master Lock Co. [Cl. 206-80.]

Fowle, Irving H. Color slide viewing accessory. U. S. pat. 2,948,975. Filed Nov. 13, 1957. 1 claim. Assigned to General Aniline & Film Corp. [Cl. 40-106.1.] The viewer is formed of paperboard.

Frankenstein, William P. Cartons. U. S. pat. 2,949,219. Filed March 12, 1956. 11 claims. [Cl. 229-31.] A carton erected by interlocking is constructed to provide interlocking of a positive sort.

Freund, Gustav, II., and Grabauskas, Joseph J. Casings, method of, and apparatus for producing same. U. S. pat. 2,949,-371. Filed Dec. 27, 1955. 16 claims. Assigned to Union Carbide Corp. [Cl. 99-176.] A regenerated cellulose sausage casing having an opaque stripe is provided.

Goldstein, Samuel. Method and machine for making triple wall corrugated paper board. U. S. pat. 2,949,151. Filed Aug. 16, 1956. 3 claims. Assigned to Tri-Wall Containers, Inc. [Cl. 154-33.05.]

Hindle, Thomas, Lord, Sam, and Race, Edward. Papermaker's felts and like industrial woven textile fabrics. U. S. pat. 2,949,134. Filed Aug. 15, 1956. 15 claims. Assigned to Scapa Dryers, Ltd. [Cl. 139-426.] The felt, including synthetic fibers, is formed so as to be electrostatically neutral and hence resistant to collecting dirt and fibers while in use.

Huck, William F. Web tension control mechanism. U. S. pat. 2,949,295. Filed Aug. 8, 1957. 10 claims. Assigned to Huck Co. [Cl. 271-2.3.]

Hughes, William L. Package. U. S. pat. 2,949,370. Filed Sept. 23, 1957. 14 claims. Assigned to Ree-Ceel Corp. [Cl. 99-173.] A reclosable bag of paper or the like is provided with a permanent seal and a secondary resealable device formed of pressure-sensitive tape.

Kraft, George H., Grossen, Harry W., and Bell, Kenneth. Packaging. U. S. pat. 2,949,372. Filed May 3, 1954. (Divided; original filed June 19, 1951.) 2 claims. Assigned to National Dairy Prods. Corp. [Cl. 99-178.] Heated cheese is formed into a neat pack wrapped in a tissue-foil laminate.

La Bombard, Leon E. Method and apparatus for creasing blanks. U. S. pat. 2,949,066. Filed Jan. 20, 1958. 15 claims. Assigned to Intern. Paper Box Machine Co. [Cl. 93-58.3.] Improved blank-feeding and registering means are provided.

Levkoff, David. Cartons. U. S. pat. 2,949,220. Filed June 4, 1958. (Divided; original filed May 7, 1956.) 1 claim. Assigned 25% to Evelyn S. Levkoff, 25% to Henry S. Levkoff, and 25% to Edith L. Sennet. [Cl. 229-31.] A produce-packing tray is provided.

Malowan, John E., and Nielsen, Morris L. Fire-retardant process. U. S. pat. 2,949,385. Filed Jan. 27, 1953. 1 claim. Assigned to Monsanto Chemical Co. [Cl. 117-138.] Cellulosic materials are treated with a hydrolyzed derivative of the reaction product of phosphorus oxychloride and anhydrous ammonia.

Meissner, Scott C. Floral gift photograph and sympathy card folder. U. S. pat. 2,948,977. Filed Oct. 1, 1954. 1 claim. [Cl. 40-158.]

Owens, Thomas M. Removing impurities from fluid suspensions. U. S. pat. 2,949,187. Filed March 28, 1957. 7 claims [Cl. 209-2.] An apparatus is provided for cleaning papermaking stocks, particularly those formed from wastepaper.

Pugh, William A., Sr. One-piece carton and sipper straw holder. U. S. pat. 2,949,217. Filed Oct. 7, 1958. 5 claims. [Cl. 229-17.]

Savage, Albert B. Process for preparing alkyl hydroxyalkyl cellulose ethers and the product obtained thereby. U. S. pat. 2,949,452. Filed April 30, 1956. 8 claims. Assigned to the Dow Chem. Co. [Cl. 260-231.]

Sloan, Francis J. Display and collapsible cartons. U. S. pat. 2,949,218. Filed Jan. 7, 1957. 11 claims. Assigned to Package Machinery Co. [Cl. 229-28.] Plastic membranes hold fragile articles out of contact with the walls of a carton.

Smith, Leon E. Leaf match case assembly. U. S. pat. 2,949,-180. Filed Jan. 25, 1960. 3 claims. [Cl. 206-48.] A device is provided which supports a book of matches on its front face and holds a pack of cigarettes within the body of the device.

Steinhardt, David W. Duplicating sheet coated with a colorless waxy transfer material. U. S. pat. 2,949,381. Filed April 4, 1958. 2 claims. [Cl. 117-36.]

Steinhardt, David W., Steinhardt, Amos, and Goldwater, Franklin A. Transfer composition containing a triphenylcarbinol compound and precipitated calcium carbonate. U. S. pat. 2,949,377. Filed Oct. 30, 1957. 2 claims. [Cl. 106-272.] A coloring composition is provided for use in transfer duplicating processes, e.g., in a coating for carbonless carbon paper, spirit process masters, etc.

Thiegs, Bernard J. Stabilized foam-providing compositions. U. S. pat. 2,949,426. Filed May 21, 1957. 5 claims. Assigned to the Dow Chem. Co. [Cl. 252-307.] Cellulose ethers are used.

Töppel, Otmar. Neutralizing lignin-containing liquors. U. S. pat. 2,949,448. Filed June 15, 1954. 5 claims. Assigned to Firma Aschaffenburger Zellstoffwerke A. G. [Cl. 260-124.] Liquors such as spent sulfite liquors which have undergone alkaline and oxidizing treatments are neutralized with carbon dioxide followed by addition of an acid-reacting salt.

Vander Lugt, Thomas, Jr. Carton. U. S. pat. 2,949,221. Filed April 27, 1959. 6 claims. Assigned to KVP Sutherland Paper Co. [Cl. 229-40.] A window carton for a slab of bacon slices has a parallelogram configuration when viewed from the end, but retains adequate stacking strength.

von Hazmburg, Romulus S. Pulp process. U. S. pat. 2,949,-395. Filed Jan. 12, 1956. 3 claims. [Cl. 162-84.] A semichemical pulping process is described.

Werner, Tyrrell H., Marra, William H., and Gilman, Warren B. Mineral filled paper. U. S. pat. 2,949,397. Filed June 13, 1955. 9 claims. Assigned to S. D. Warren Co. [Cl. 162-178.] The filler comprises mineral particles coated with a plant mucilage such as guar gum.

Zoeller, Richard J., and Henderson, James R. Compartmented dough package. U. S. pat. 2,949,369. Filed Oct. 29, 1956. 2 claims. Assigned to Pillsbury Co. [Cl. 99-172.] A spiral-wound paper container with metal ends is provided with an internal disk partition for separating different components being packed.

Zwarycz, Michael. Heater for wrapping machine. U. S. pat. 2,949,001. Filed March 3, 1958. 8 claims. Assigned to Crompton & Knowles Packaging Corp. [Cl. 53-141.] Means are provided to prevent deposit of particles of wrapping material onto the heat-sealing surfaces of a wrapping machine.

Zwarycz, Michael. Wrapper feed mechanism. U. S. pat. 2,949,002. Filed April 22, 1959. 10 claims. Assigned to Crompton & Knowles Packaging Corp. [Cl. 53-389.] A wrapping sheet is held taut for the initial step of wrapping items therein.

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Acomb, Frederick G. Merchandising display package. U. S. pat. 2,950,004. Filed Nov. 14, 1957. 1 claim. [Cl. 206-78.] A display package for a circular sawblade comprises a paperboard backing and a plastic cover sheet.

Austin, Marshall M. Reclosable folding box and method of making it. U. S. pat. 2,950,044. Filed Jan. 19, 1959. 10 claims. Assigned to Baljak Corp. [Cl. 229-44.]

Balough, Harold O. Blanket applying and replacing means and method. U. S. pat. 2,950,224. Filed Dec. 12, 1958. 12 claims. Assigned to Clupak, Inc. [Cl. 162-199.] The blanket is used in the paper machine section effecting mechanical deformation of the paper web in the manufacture of stretchable paper.

Berry, Donald S. Machines for folding paper sheets. U. S. pat. 2,950,105. Filed Oct. 22, 1957. 12 claims. Assigned to Sun Printers, Ltd. [Cl. 270-72.] The pages in a printed signature or the like are all folded so that they lie flat after folding.

Bletzinger, John C., and Allan, Lawrence H. Cellulosic product. U. S. pat. 2,950,223. Filed Aug. 6, 1956. 10 claims. Assigned to Kimberly-Clark Corp. [Cl. 162-114.] Creped tissue or toweling is mechanically treated to improve the softness and absorbency of the material during use without compacting the web.

Bolding, Hubert V. Carton having simulated band. U. S. pat. 2,950,040. Filed Oct. 1, 1959. 3 claims. Assigned to Standard Pkg. Corp. [Cl. 229-38.] A paper band carrying advertising indicia is attached to a carton blank so that when the blank is erected the band encircles the carton.

Clark, James d'A. Method for forming fibrous structures. U. S. pat. 2,949,646. Filed Nov. 24, 1953. 6 claims. Assigned to Changewood Corp. [Cl. 19-155.] A method is provided for the air-deposition of fibers to form shaped mats which may be of odd shape.

Covington, Edward R., and Meier, John W. Packaging film and process for preparation thereof. U. S. pat. 2,950,218. Filed July 23, 1957. 20 claims. Assigned to E. I. du Pont de Nemours & Co. [Cl. 117-145.] A composition of vinylidene chloride, isopropenyl acetate, and acrylonitrile provides heat-sealability for paper, cellophane, etc.

Davis, Robert F. Lost container switch mechanism for automatic packaging equipment. U. S. pat. 2,949, 714. Filed Dec.

3, 1958. 4 claims. Assigned to Wise Potato Chip Co. [Cl. 53-63.] A machine for filling paper bags or the like is provided with means which cancel out the packaging cycle when a bag is not fed or is fed improperly.

Di Maio, Vincent, and Miller, Norman T. Pipe insulator and method of making same. U. S. pat. 2,949, 953. Filed May 26, 1955. 9 claims. [Cl. 154-28.] A pipe-insulating unit comprises a specially prepared mat of glass fibers fixed between paper facing sheets.

Fromer, Stephen. Suntan control device. U. S. pat. 2,949,-880. Filed July 17, 1958. 3 claims. [Cl. 116-114.] A photosensitive paper device is used to indicate time of exposure to sunlight.

Goldstein, Arnold. Barbecue package. U. S. pat. 2,950,042. Filed Oct. 21, 1959. 2 claims. [Cl. 229-41.] A carton is provided for holding the various parts of a disassembled home barbecue unit.

Gundlach, Robert W. Stencil master making. U. S. pat. 2,949,849. Filed July 27, 1955. 4 claims. Assigned to Haloid Xerox, Inc. [Cl. 101-128.3.] This is similar to U. S. pat. 2,949,-848 (Aug. 23, 1960).

Haug, Anton J. Two stage pulp refining machine. U. S. pat. 2,950,064. Filed May 29, 1957. 5 claims. [Cl. 241-46.]

Heuer, Kurt, Elling, Hugo, and Elssner, Richard. Production of shaped objects from viscose. U. S. pat. 2,950,208. Filed Oct. 21, 1959. (Divided; original filed Oct. 17, 1955.) 4 claims. Assigned to Am. Enka Corp. [Cl. 106-165.] Certain metal-amine complex compounds are added to improve strength and elasticity.

Johnson, Donald L. Means for producing flakes while cutting a flat surface on wood. U. S. pat. 2,949,946. Filed March 28, 1958. 6 claims. [Cl. 144-162.]

Jones, Frederick B. Production of filaments having improved whiteness. U. S. pat. 2,950,207. Filed Nov. 7, 1957. 6 claims. Assigned to Am. Enka Corp. [Cl. 106-165.] Titanium dioxide and organic pi ments are added to the viscose.

Kempen, Raymond J., and Newell, Walter L. Manufacture of box blanks from box board. U. S. pat. 2,949,827. Filed June 11, 1958. 9 claims. Assigned to Alton Box Board Co. [Cl. 93-58.] An improved method is provided for scoring and creasing box blanks.

Kernan, James M., and Lewis, Russell L. Apparatus primarily for testing opening force and flap score stiffness characteristics of cartons. U. S. pat. 2,949,770. Filed Feb. 14, 1958. 4 claims. Assigned to Pkg. Corp. of America. [Cl. 73-93.]

Kirkpatrick, Willard H. Polyoxyalkylene esters of tall oil rosin acids. U. S. pat. 2,950,272. Filed March 25, 1957. 6 claims. Assigned to Visco Prods. Co. [Cl. 260-104.] The esters are used in petroleum emulsion breakers.

Lichtblau, Ellis I. Impregnation process. U. S. pat. 2,950,217. Filed Nov. 13, 1956. 5 claims. Assigned to E. I. du Pont de Nemours & Co. [Cl. 117-144.] Regenerated cellulose articles are treated with quaternary ammonium chloride to permit their storage in the gel state.

Losse, Paul L. Method of making insulation blocks and shapes. U. S. pat. 2,950,225. Filed Jan. 21, 1955. 2 claims. Assigned to Eagle-Picher Co. [Cl. 162-201.] A fiber-binder slurry is cast into blocks and the blocks are sawed into slabs.

MacDonald, Duncan N. Card sorter. U. S. pat. 2,950,005. Filed Aug. 10, 1956. 5 claims. Assigned to Burroughs Corp. [Cl. 209-74.] Paper cards carrying coded information in the form of a magnetic sorting bit are sorted.

Malnove, Paul. Merchandising display device. U. S. pat. 2,950,013. Filed May 3, 1956. 1 claim. [Cl. 211-86.] A shelflike device, apparently formed of paperboard, is provided for supporting merchandise upon the shelves or counters of a retail store.

Martin, Hugh M. Combined statement and return envelope. U. S. pat. 2,950,045. Filed June 4, 1958. 1 claim. Assigned 50% to Francis C. Hunt. [Cl. 229-92.3.]

Mazer, Marshall, and Vosmer, Harry N. Record member. U. S. pat. 2,950,050. Filed March 4, 1957. (Divided; original filed Nov. 9, 1955.) 1 claim. Assigned to the Natl. Cash Register Co. [Cl. 235-61.12.] A business machine record member comprises a paper base marked with a fluorescing sublimable anthracene/naphthacene mixture.

Mott, George R. Stencil making. U. S. pat. 2,949,848. Filed July 27, 1955. 7 claims. Assigned to Haloid Xerox, Inc. [Cl. 101-128.3.] A xerographic method is provided for preparing a duplicating stencil.

Orsini, René. Packages for liquid, pasty and pulverulent materials. U. S. pat. 2,950,037. Filed Aug. 9, 1957. 5 claims. Assigned to S. A. Plastus. [Cl. 229-14.] The package comprises a plastic bag secured within a paperboard carton.

Ostergren, Jarl O. B. Finishing mortars. U. S. pat. 2,950,-206. Filed March 14, 1956. 3 claims. Assigned to Nya Murbruksfabrikens i Stockholm Aktiebolag. [Cl. 106-119.] Cellulose ethers are used.

Pigott, Owen R., and Sproat, Kenneth A. Packing of powdery or granular materials. U. S. pat. 2,949,844. Filed July 30, 1958. 7 claims. Assigned to Imperial Chemical Inds., Ltd., [Cl. 100-144.] An apparatus is provided for flattening a multi-ply paper bag filled with a powdery or granular material.

Plunkett, Warren L. Manufacture of nitrocellulose. U. S. pat. 2,950,278. Filed April 15, 1957. 10 claims. Assigned to Hercules Powder Co. [Cl. 260-220.]

Ringler, William A. Carton. U. S. pat. 2,950,043. Filed April 2, 1956. 1 claim. Assigned to Diamond Natl. Corp. [Cl. 229-44.] A blank is provided which may be set up to form a flip-top cigarette box by existing cigarette-wrapping machines.

Royer, Arthur G. Continuous sheet feeding method and pallet therefor. U. S. pat. 2,950,107. Filed Nov. 25, 1957. 21 claims. Assigned to Harris Intertype Corp. [Cl. 271-61.] A pallet is provided for supporting a pile of paper in a continuous-type pile-elevating sheet-feeder.

Rupp, Charles E. Packing pad. U. S. pat. 2,950,038. Filed Sept. 6, 1957. 1 claim. Assigned to Pkg. Corp. of America. [Cl. 229-14.] An interior packing device comprises several sheets of corrugated secured together so that all can be folded to right-angle configuration at once.

Schrier, Harold D. Coating composition. U. S. pat. 2,950,-210. Filed Dec. 8, 1958. 2 claims. [Cl. 106-230.] The composition provided renders the base material, such as paper, heat-sealing and nonblocking.

Smith, John W. Cast coated paper and method of making the same. U. S. pat. 2,950, 214. Filed March 25, 1957. 15 claims. Assigned to Mead Corp. [Cl. 117-64.]

Stone, Orison W. Wrap-around paperboard carrier. U. S. pat. 2,950,041. Filed Nov. 29, 1957. 7 claims. Assigned to Continental Can Co., Inc. [Cl. 229-40.] A tubular open-end carton is provided for unitizing a row of crown-top cans.

Streck, Clemens. Hectograph carbon paper. U. S. pat. 2,950,-213. Filed Aug. 31, 1956. 3 claims. Assigned to General Aniline & Film Corp. [Cl. 117-36.]

Vergobbi, John G. Lined carton and method of making the same. U. S. pat. 2,950,036. Filed July 16, 1957. 5 claims. Assigned to Pneumatic Scale Corp. [Cl. 229-14.] The liner and carton blank are erected together, with the bottom closure being formed to be leakproof.

Vogt, Clarence W. Method and apparatus for filling containers. U. S. pat. 2,949,711. Filed July 2, 1956. 18 claims. [Cl. 53-24.] This is similar to U. S. pat. 2,949,713 (Aug. 23, 1960.)

Vogt, Clarence W. Method and apparatus for forming and filling packages. U. S. pat. 2,949,713. Filed May 18, 1956. 15 claims. [Cl. 53-29.] A plastic sheet is deformed into pockets, the pockets are filled, and a sheet of paper is sealed over the open face of the pockets.

Von Rudeen, Dolf. Cigarette package. U. S. pat. 2,950,060. Filed Feb. 17, 1958. 2 claims. [Cl. 229-44.] The hinged closure elements at the upper end of a cigarette box are opened by pushing upward on the bottom of the box.

Wikle, Richard H. Crinkled paper product and means and method of forming same. U. S. pat. 2,949,954. Filed June 14, 1955. 7 claims. [Cl. 154-30.] A creping method is employed to crinkle paper so that it is stretchable in a number of directions suitable for use as bag paper.

Wilson, James C. Receptacle. U. S. pat. 2,950,039. Filed Jan. 10, 1958. 6 claims. Assigned to Owens-Illinois Glass Co. [Cl. 229-14.] A polygonal carton with dispensing openings is provided for carrying a plastic bag holding a liquid.

Windover, Francis E. Frozen confection and method of making the same. U. S. pat. 2,950,199. Filed March 30, 1956. 9 claims. Assigned to the Dow Chem. Co. [Cl. 99-136.] Carboxymethylcellulose and other cellulose derivatives are used.

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Ardner, Robert L. Transfer mechanism. U. S. pat. 2,950,-804. Filed Jan. 12, 1959. 3 claims. Assigned to Lynch Corp. [Cl. 198-24.] In a packaging machine, articles are transferred from a conveyor to an elevator for upward movement through a wrapper-folding way.

Backhouse, Headley T. Sheet feeding machines. U. S. pat. 2,950,916. Filed July 2, 1958. 3 claims. [Cl. 271-60.] An improved front lay construction is provided for registering each sheet.

Bennett, Thomas R. Web-renewing mechanism. U. S. pat. 2,950,874. Filed Feb. 23, 1956. 7 claims. Assigned to R. W. Crabtree & Sons, Ltd. [Cl. 242-58.3.] A mechanism for automatically changing from an expired to a new web supply roll is provided with means to actuate the change.

Bernhardt, Daniel. Package sealer. U. S. pat. 2,951,141. Filed Sept. 11, 1958. 1 claim. [Cl. 219-19.] In a heat-sealer, the user's hands are protected from the sealing mechanism.

Brillhart, William O., Gallant, LeRoy, and Carver, James N. Cellophane coating having improved wet strength at low temper-

atures. U. S. pat. 2,950,992. Filed Aug. 12, 1957. 10 claims. Assigned to Am. Viscose Corp. [Cl. 117-144.]

Corcoran, James P. Carton construction. U. S. pat. 2,950,850. Filed Nov. 20, 1958. 8 claims. Assigned to Packaging Corp. of Am. [Cl. 229-16.] A ventilated paperboard carton is provided for replacing wooden bushel baskets in the packaging of produce.

Dain, John E., and Phelps, Richard W. Paper machinery. U. S. pat. 2,950,875. Filed May 6, 1957. 4 claims. Assigned to Black-Clawson Co. [Cl. 242-66.] The rider roll of a web winder is designed so that the pressure exerted on the winding roll is decreased in proportion to the increase in diameter of the winding roll.

Deacon, Frederick S., and Wheeler, Ralph W., Jr. Method of producing printed surface covering and printing enamel therefor. U. S. pat. 2,950,988. Filed Oct. 9, 1956. 11 claims. Assigned to Congoleum-Nairn Inc. [Cl. 117-38.]

Fleissner, Gerold. Willow driers. U. S. pat. 2,950,540. Filed Sept. 24, 1956. 5 claims. Assigned to Fleissner & Sohn Maschinenfabrik. [Cl. 34-115.] Means are provided for moving loose fibrous material across the tops of several drier drums.

Folta, Andrew. Method for making bobbins. U. S. pat. 2,950,527. Filed Dec. 11, 1956. 5 claims. Assigned to Precision Paper Tube Co. [Cl. 29-458.] End flanges are secured to a rectangular open-end core formed of laminated paper covered with cellulose acetate.

Freeman, Eben W. Method of producing drum-finished coated paper. U. S. pat. 2,950,989. Filed March 17, 1958. 13 claims. Assigned to S. D. Warren Co. [Cl. 117-64.]

Ganz, Robert H. Carton. U. S. pat. 2,950,854. Filed Feb. 27,1959. 5 claims. Assigned to Continental Can Co., Inc. [Cl. 229-40.] A wrap-around open-end carton is provided for unitizing several jars or bottles, with cushioning means between the items being provided.

Gausman, Alfred P. Automatic packaging machines. U. S. pat. 2,950,588. Filed Dec. 24, 1958. 10 claims. Assigned to Hayssen Mfg. Co. [Cl. 53-51.] Various improvements are made in a packaging machine in which a tube of packaging material is formed, filled, and transversely sealed to form a continuous series of packages.

Gewiss, Lucien V. Arrangement for the mechanical and continuous production of developable herring-bone structures. U. S. pat. 2,950,656. Filed Jan. 15, 1959. 17 claims. Assigned to Marc Wood, Société Anonyme pour la Promotion des Echanges Techniques Internationaux. [Cl. 93-1.] Paper is folded into a pleated configuration of use in various applications.

Golding, William F. Sheet feed and registration apparatus. U. S. pat. 2,950,915. Filed March 25, 1957. 10 claims. [Cl. 271-50.] The sheet-feeder is similar to that of U. S. pat. 2,950,914 (Aug. 30, 1960).

Golding, William F. Sheet feeding apparatus. U. S. pat. 2,950,914. Filed Nov. 22, 1957. 9 claims. [Cl. 271-45.] The sheet-feeder is designed for a paperboard embossing press.

Hillman, Swan. Automatic packaging machine. U. S. pat. 2,950,894. Filed Oct. 1, 1956. 6 claims. [Cl. 249-2.] An apparatus for packaging screws is provided with a feeding mechanism which first feeds a bulk quantity of screws, then brings the load up to the desired weight by dribble-feeding.

Hirsch, Arthur. Adhesive compositions. U. S. pat. 2,950,980. Filed Sept. 10, 1958. 1 claim. [Cl. 106-125.] A dispersion of animal glue and urea is used as a packaging adhesive which can be activated by either heat or moisture.

Hoofer, Charles F. Sheet holding and dispensing device. U. S. pat. 2,950,821. Filed Oct. 25, 1956. 2 claims. [Cl. 211-54.] A small device including a base, an upright prong, and a spring clamp is provided for retaining a stack of papers and permitting dispensing of single sheets.

Howard, Edward G., Jr. Thermally-sensitive recording elements. U. S. pat. 2,950,987. Filed Oct. 28, 1958. 4 claims. Assigned to E. I. du Pont de Nemours & Co. [Cl. 117-36.] The elements are paper-base.

Huber, John R. Net equipment for open rack vehicles. U. S. pat. 2,950,691. Filed June 10, 1958. 15 claims. Assigned to Eastern Rotorcraft Corp. [Cl. 105-369.] Special net equipment is provided to prevent lateral movement of the upper part of a load of logs on a railroad car.

Hutchison, George A. Tote box. U. S. pat. 2,950,852. Filed Oct. 30, 1957. 12 claims. Assigned to Rathborne, Hair & Ridgway Box Co. [Cl. 229-23.] The open-top tote box is set up without external fasteners and includes wooden reinforcing frames and a partitioning element.

Larios, Daniel. Foldable frame. U. S. pat. 2,950,556. Filed Nov. 19, 1958. 7 claims. Assigned 50% to William E. Ford. [Cl. 40-154.] A picture frame of three-dimensional form is erected from a paperboard blank.

Leighton, Henry B. Bilingual communicator. U. S. pat. 2,950,544. Filed Nov. 17, 1958. 6 claims. [Cl. 35-35.] An assembly of superposed paper sheets is used to form a device for communicating between two persons who speak different languages.

Lippke, Paul R. Method and device for regulating the moisture content of endless moving webs of fibrous material. U. S. pat. 2,951,007. Filed June 6, 1957. 14 claims. [Cl. 162-198.]

Litchard, Alexander. Bag feeding mechanism. U. S. pat. 2,950,589. Filed July 31, 1958. 11 claims. [Cl. 53-190.] Bags are fed, opened, and positioned beneath a filling chute.

Miller, Harold A., and Greenstein, Leon M. Nacreous pigment and process of preparing same. U. S. pat. 2,950,981. Filed April 10, 1957. 14 claims. Assigned to Francis Earle Labs., Inc. [Cl. 106-194.] Cellulose nitrate is compounded with a pigment to form a lacquer.

Moser, Henry W., and McGirr, George W. Continuous running machines for producing box blanks. U. S. pat. 2,950,658. Filed May 21, 1958. 8 claims. Assigned to Samuel M. Langston Co. [Cl. 93-58.] A corrugated board double-facer unit, which is followed by box-blanking apparatus, is provided with a suitable variable speed transmission.

Napier, Joe T., and MacMurray, Jess F. Pole shaving apparatus having bark breaker. U. S. pat. 2,950,743. Filed Nov. 26, 1957. 3 claims. Assigned to J. H. Baxter & Co. [Cl. 144-208.] The bark is broken into short lengths before its removal from the log.

Nelson, Seddon C. Mechanical roll changer. U. S. pat. 2,950,873. Filed Feb. 26, 1957. 9 claims. Assigned to Am. Viscose Corp. [Cl. 242-56.] A web winder is provided with means to switch from a full roll to a new core while minimizing bunching of the web at the new core.

O'Brien, Robert J., and Vold, Gordon A. Apparatus for hooding open-faced containers. U. S. pat. 2,950,590. Filed Feb. 7, 1958. 20 claims. Assigned to Ekco-Alcoa Containers, Inc. [Cl. 53-342.] A cover sheet of waxed paper or the like is folded over the top of a filled paper or foil tray.

Ortleb, Douglas B. Box construction. U. S. pat. 2,950,849. Filed Sept. 16, 1959. 3 claims. [Cl. 229-8.] A box for gift packing of candy, comprising body and cover portions each having a flat top or bottom panel which projects beyond the side wall is provided with means for attaching the side wall to the flat panel.

Peimer, Stanley L. Slide closure carton. U. S. pat. 2,950,851. Filed July 29, 1958. 17 claims. [Cl. 229-17.] The slide closure is an integral construction.

Polley, Robert W. Thermosensitive tape dispensing. U. S. pat. 2,951,140. Filed June 18, 1956. 19 claims. Assigned to Nashua Corp. [Cl. 219-19.]

Richter, Frederick H., and Snyder, Frederick B. Apparatus for avoiding digester corrosion. U. S. pat. 2,950,757. Filed Jan. 30, 1953. 11 claims. Assigned to Babcock & Wilcox Co. [Cl. 162-233.] The digester is provided with a liner screen.

Ruscito, Anthony J. Method of making an electrical condenser. U. S. pat. 2,951,002. Filed Sept. 28, 1951. 5 claims. Assigned to Bendix Corp. [Cl. 154-80.] Strips of foil and hard-calendered kraft paper are wound together.

Shiels, Robert A. Combination display shelf and divider or separator for a stack of columnar articles. U. S. pat. 2,950,820. Filed Dec. 9, 1957. 11 claims. Assigned to the Mead Corp. [Cl. 211-49.] A display rack comprises paperboard panels fixed to reinforcing frames to form shelves.

Small, Leroy J. Carton lid holder. U. S. pat. 2,950,514. Filed March 12, 1958. 5 claims. Assigned to Memphis Metal Mfg. Co., Inc. [Cl. 24-81.] Metal clips hold down the top flags of a carton during filling.

Staines, Alfred J. Sheet feeding apparatus. U. S. pat. 2,950,913. Filed Dec. 4, 1958. 20 claims. Assigned to Harris-Intertype Corp. [Cl. 271-26.] Means are provided to adjust the movement of suction elements which lift and spread each sheet.

Staley, William C. Printer-slotters. U. S. pat. 2,950,677. Filed Aug. 6, 1959. 7 claims. Assigned to Greenwood Engineering Co., Inc. [Cl. 101-350.] An improved drive is provided for the fountain roll of a printer-slotter.

Tamaccio, David L. Ticketing. U. S. pat. 2,950,555. Filed Oct. 28, 1958. 4 claims. Assigned to Soabar Co. [Cl. 40-20.] Improved means are provided for adhesively attaching a string to a piece of paper to form a string tag.

Tench, John D., Ferris, Seymour W., and Duling, Irl N. Wax compositions comprising 3–15% of a paraffin wax with a melting point of 125–135°F. and 85–97% of a paraffin wax with a melting point of 138–147°F. U. S. pat. 2,951,028. Filed Feb. 12, 1958. 3 claims. Assigned to Sun Oil Co. [Cl. 208-31.] The waxes are coating food packages.

Thomson, John W., Jr. Sealing means for empty glass containers. U. S. pat. 2,950,814. Filed Dec. 18, 1957. 4 claims. Assigned to Owens-Illinois Glass Co. [Cl. 206-65.] A die-cut paper sheet is used to temporarily seal the mouths of empty glass jars packed in a shipping carton.

van Antwerpen, Lloyd D. Shipping carton for wrap-around

rear windows and windshields of automobiles. U. S. pat. 2,950,-812. Filed Nov. 7, 1955. 1 claim. [Cl. 206-62.]

Washburn, Robert S. Paper drier. U. S. pat. 2,951,139. Filed May 22, 1958. 9 claims. Assigned to Beloit Iron Works. [Cl. 219-10.61.] The drying efficiency of a Yankee drier is improved by using supplemental high-frequency heating.

Weiss, Thomas B. Folded container. U. S. pat. 2,950,853. Filed March 10, 1955. 2 claims. [Cl. 229-24.] A rectangular blank is erected to form an open-top container to which a bail handle may be attached.

Wheat, Vernon D., and Hadfield, Walter. Permanent crimping process. U. S. pat. 2,950,521. Filed May 22, 1957. 5 claims. Assigned to Am. Viscose Corp. [Cl. 28-72.] Cellulose ethers are used in a process for treating cellulosic yarns.

Withers, Louis A. Paper glove and method and apparatus for producing same. U. S. pat, 2,950,482. Filed June 18, 1956. 6 claims. [Cl. 2-169.]

Zahner, Oscar A. Expense record packet and method of making. U. S. pat. 2,950,855. Filed July 3,1958. 2 claims. [Cl. 229-72.] A file folder has space for recording expenses, and pockets for storing vouchers supporting the expense entries.

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Apel-Alfons. Selective saccharification of cellulosic materials. U. S. pat. 2,951,775. Filed Dec. 12, 1957. 4 claims. Assigned to UDIC Société Anonyme. [Cl. 127-37.]

Bernart, William F., and Hanson, Walter J. Collating machine. U. S. pat. 2,951,697. Filed Nov. 23, 1956. 3 claims. Assigned to Pitney-Bowes, Inc. [Cl. 270-58.]

Brenker, Hans. Closure means for bags. U. S. pat. 2,951,-273. Filed Jan. 22, 1958. 8 claims. Assigned to Neoplastik Braunschweiger Kunststoffwerk G.m.b.H. [Cl. 24-30.5.] A device is provided to clamp about the gathered neck of a bag as a closure and handle.

Butler, Charles K. Method for continuously fabricating an impervious metal coated fibrous glass sheet. U. S. pat. 2,951,-771. Filed Nov. 5, 1956. 4 claims. Assigned to Owens-Corning Fiberglas Corp. [Cl. 117-114.]

Cumpston, Edward H., Jr. Wood shaving machine with rotary cutter head and feeding means. U. S. pat. 2,951,518. Filed Jan. 20, 1955. 11 claims. Assigned to E. D. Jones Corp. [Cl. 144-172.]

Davidson, Louis. Folding industrial pallet. U. S. pat. 2,951,669. Filed April 17, 1957. 13 claims. [Cl. 248-120.] The pallet is made of paperboard.

Dorman, Isidore, and Hoos, Curtis G. Wrapping machine. U. S. pat. 2,951,326. Filed April 7, 1958. 12 claims. [Cl. 53-194.] Individual pieces of candy are wrapped.

Erickson, Harold E., and Robinson, Curville J. Ram-type wood reducing apparatus. U. S. pat. 2,951,519. Filed Aug. 18, 1958. 7 claims. Erickson's interest assigned to Dale L. Schubert, and Robinson's interest assigned to Industrial Devt. Co., Inc. [Cl. 144-172.] Wood is reduced to flakes for use in composition board.

Flynn, Stanley F. Egg crate or case fillers or trays. U. S. pat. 2,951,605. Filed June 4, 1958. 10 claims. [Cl. 217-35.] The trays are made of molded plastic.

Grussen, Jean. Container for fluid or pulverulent material and process for making it. U. S. pat. 2,951,628. Filed Nov, 19, 1956. 5 claims. [Cl. 229-55.] A plastic bag is sandwiched between two protective kraft paper sheets which also form a handle element for the container.

Haab, Gordon W. Casing machine. U. S. pat. 2,951,323. Filed April 30, 1956. 22 claims. [Cl. 53-61]. The machine places cans, milk bottles, or paper milk cartons into shipping cases.

Haley, Theodore G. Sheet dispensing starter. U. S. pat. 2,951,623. Filed April 2, 1959. 14 claims. [Cl. 225-54.] A carton for holding and dispensing a roll of household wrapping material is provided with means for starting the material through the dispensing slot.

Kelly, Harold C., and Wirt, James R. Composition and process for coating foodstuffs and articles thereby obtained. U. S. pat. 2,951,763. Filed June 9, 1958. 8 claims. [Cl. 99-169.] Ethylcellulose is used.

Lockwood, Harry A. Humidity indicator device and combination thereof with container. U. S. pat. 2,951,461. Filed Nov. 12, 1958. 5 claims. [Cl. 116-114.]

Lodge, James R., and Fehner, Robert H. Method of making artificially colored granules, coating compositions employed therein and color-coated granule product thereof. U. S. pat. 2,951,770. Filed April 9, 1957. 5 claims. Assigned to Minnesota Mining and Mfg. Co. [Cl. 117-100.] The granules are of use in coating roofing materials.

McCants, James F. Preservative composition for cellulosic materials comprising heavy metal soaps. U. S. pat, 2,951,789. Filed Dec. 27, 1955. 3 claims. Assigned to Pan American Petroleum Corp. [Cl. 167-38.5.]

Marban, Teodoro E. G. Box construction. U. S. pat. 2,951,-625. Filed March 14, 1958. 1 claim. Assigned to Heinrich Envelope Co. [Cl. 229-20.] A telescoping carton is provided for packaging a pack of bank check blanks or the like.

Moore, Theodore R. Paper making machine. U. S. pat. 2,951,784. Filed June 25, 1957. 12 claims. Assigned to Olin Mathieson Chemical Corp. [Cl. 162-212.] Improved stock circulation is provided in a cylinder vat machine.

Novick, Abraham. Mechanism for cutting, notching and feeding diamond shaped envelope blanks. U. S. pat. 2,951,408. Filed Nov. 17, 1954. 30 claims. Assigned to F. L. Smithe Machine Co., Inc. [Cl. 83-88.]

Podlesak, Harry G., George H., and Miller, Roland E. Packaging apparatus. U. S. pat. 2,951,324. Filed Dec. 3, 1956. 10 claims. Assigned to Natl. Dairy Prods. Corp. [Cl. 53-112.] Means are provided to press a wrapper sheet into close contact with an item without wrinkling the wrapper.

Podlesak, Harry G., Kraft, George H., and Miller, Roland E. Sealing and severing mechanism. U. S. pat. 2,951,325. Filed Dec. 7, 1956. 1 claim. Assigned to Natl. Dairy Prods. Corp. [Cl. 53-182.] The operations are performed on a continuous tube of packaging material containing a series of spaced articles so as to form a separate wrapped pack for each article.

Saltz, Morris A. Drapery pin hook package and holder. U. S. pat. 2,951, 249. Filed Nov. 4, 1957. 6 claims. [Cl. 1-56.]

Sanford, Stuart P. Display carton. U. S. pat. 2,951,583. Filed May 12, 1958. 2 claims. Assigned to Westinghouse Elec. Corp. [Cl. 206-45.13.] The carton is for packaging a number of small articles such as small electric lamps.

Schwebs, Robert K. Produce container and tray insert. U. S. pat. 2,951,624. Filed Jan. 10, 1958. 6 claims. Assigned to Cornell Paperboard Prods. Co. [Cl. 229-15.] A cellular stackable paperboard tray is provided for packaging produce.

Wasserkrug, Jerome G. Display stand. U. S. pat. 2,951,592. Filed June 24, 1959. 8 claims. Assigned to Langendorf United Bakeries, Inc. [Cl. 211-135.] The steplike stand provided is for displaying loaves of bread.

Weiss, Adolph. Box construction. U. S. pat. 2,951,626. Filed Feb. 8, 1956. 8 claims. [Cl. 229-44.] The box is a flip-top cigarette box.

Wenzel, Frederick A. Snap to cardboard box. U. S. pat. 2,951,627. Filed Sept. 10, 1956. 2 claims. Assigned to Cornell Pbd. Prods. Co. [Cl. 229-44.] The box resembles a flip-top cigarette box.

Wood, William M. Automatic packaging machine and method of forming a tube from a web. U. S. pat, 2,951,322. Filed Nov. 28, 1958. 17 claims. Assigned to Laukhuff-Pratt Mfg. Corp. [Cl. 53-28.]

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Brereton, Gilbert. Harvesting and decorticating machines. U. S. pat. 2,952,044. Filed June 22, 1954. 6 claims. [Cl. 19-12.]

Brunsing, Rex L. Multiple can package. U. S. pat. 2,952,-355. Filed Dec. 31, 1956. 5 claims. [Cl. 206-65.]

Bunting, Alwyn R. Collating machine. U. S. pat. 2,952,456. Filed May 22, 1959. 24 claims. [Cl. 270-58.]

Burgeni, Alfred A. Absorbent product. U. S. pat. 2,952,-259. Filed April 18, 1956. 10 claims. Assigned to Personal Prods. Corp. [Cl. 128-290.] A sanitary napkin core comprises a folded length of wood pulp with paper inserts between layers.

Burgeni, Alfred A. Absorbent product. U. S. pat. 2,952,260. Filed April 23, 1958. 28 claims. Assigned to Personal Prods. Corp. [Cl. 128-290.] The core of sanitary napkin or the like is formed from a number of plies of wood pulp or the like which are prepared in a prescribed fashion.

Bush, Louis. Filters. U. S. pat. 2,952,333. Filed March 4, 1959. 3 claims. Assigned to Flanders Filter, Inc. [Cl. 183-71.] An air filter includes a pleated element of glass paper with corrugated separators between folds.

Carter, Walter C., and Smith, Edgar D. Process for dyeing shaped articles. U. S. pat. 2,952,505. Filed Oct. 14, 1953. 8 claims. Assigned to Chemstrand Corp. [Cl. 8-21.] Cellulosic fibers in admixture with fibers of an acrylonitrile polymer are dyed.

Chamberlin, Coleman R. Self adhesive label holder. U. S. pat. 2,952,087. Filed Nov. 13, 1958. 1 claim. [Cl. 40-16.] An assembly of paperboard and plastic forms a flat holder for a label or similar indicia-bearing device.

Condax, Louis M. Mordanted photographic imbibition dye printing blank. U. S. pat. 2,952,566. Filed Oct. 30, 1956. 1 claim. Assigned to Eastman Kodak Co. [Cl. 117-83.]

Doyle, James F. Bags, composite material and method of making. U. S. pat. 2,952,397. Filed Aug. 6, 1954. 5 claims. Assigned to Arkell Safety Bag Co. [Cl. 229-55.] A stretchable bag is formed of three plies of crinkled and corrugated paper.

Finke, Ernst A. Method and apparatus for making bags of thermoplastic tubing. U. S. pat. 2,952,299. Filed Aug. 16,

1955. 11 claims. Assigned to Windmoller & Holscher. [Cl. 154-42.]

Fliegner, Horst. System for separating and conveying flat articles. U. S. pat. 2,952,457. Filed Feb. 28, 1957. 5 claims. Assigned to International Standard Electric Corp. [Cl. 271-12.] Means for separating envelopes or the like from a stack are designed to prevent the feeding of more than one at a time.

Freud, Manfred H., and Frasch, Jean. Process for the modification of fibrous materials. U. S. pat. 2,952,580. Filed Jan. 31, 1955. 20 claims. [Cl. 162-158.] A method of filling paper is provided.

Fuller, Homer H. Machine for wrapping thick butt shingle. U. S. pat. 2,952,107. Filed July 9, 1959. 13 claims. Assigned 50% to Asphalt Equipment and Eng. Co., 25% to Edward O. Sider, and 25% to Container Corp. of America. [Cl. 53-209.]

Gerard, George A. Padded shipping bag. U. S. pat. 2,952,398. Filed Oct. 29, 1957. 1 claim. Assigned to Jiffy Mfg. Co. [Cl. 229-55.] A two-compartment container is provided: a padded bag for packing a book, and a compartment for containing an invoice or the like.

Gibson, Thomas M. Apparatus for reeling wet paper. U. S. pat. 2,952,201. Filed Nov. 23, 1956. 2 claims. Assigned to Consolidated Electrodynamics Corp. [Cl. 95-94.]

Gross, Theodore J. Box gauge. U. S. pat. 2,952,076. Filed Sept. 10, 1957. 2 claims. Assigned to Union Bag-Camp Paper Corp. [Cl. 33-165.] The gage provided is designed to be placed inside an empty box to provide measurement of the inside dimensions of the box.

Grubelic, Nocholas. Device for moistening envelope and cutting and applying the cut stamp to the envelope. U. S. pat. 2,952,375. Filed March 6, 1957. 15 claims. Assigned to Pervi Auto Stamp Corp. [Cl. 216-29.]

Hollis, Robert F. Corrugator steam system. U. S. pat. 2,952,297. Filed May 23, 1957. 4 claims. Assigned to Alton Box Board Co. [Cl. 154-33.05.]

Long, Francis L., and Long, Donald E. Method of making a packaged frozen egg product. U. S. pat. 2,952,551. Filed July 18, 1955. 3 claims. [Cl. 99-196.] An egg mixture is frozen into a cylindrical carton, which is then sliced along with the contents.

Majanlahti, Vaino E. Suction moulds. U. S. pat. 2,952,317. Filed Sept. 7, 1956. 8 claims. Assigned to Paper Machinery Ltd. [Cl. 162-357.] Improved water-evacuation means are provided in a suction cylinder for dewatering pulp.

Marshall, Harry B., and Shaw, Alan C. Production of a tanning agent from waste sulphite liquor by solvent extraction. U. S. pat. 2,952,507. Filed Nov. 24, 1958. 12 claims. Assigned to Ontario Research Foundation. [Cl. 8-94.31.]

Mitchell, Reid L. Viscose process and products produced thereby. U. S. pat. 2,952,508. Filed Sept. 16, 1953. 5 claims. Assigned to Rayonier, Inc. [Cl. 18-54.] A method is provided for producing high-strength all-skin rayon filaments.

Orloff, Daniel L. Labeling machine. U. S. pat. 2,952,376. Filed Jan. 31, 1958. 11 claims. Assigned to Oscar Mayer & Co., Inc. [Cl. 216-55.]

Parlour, A. Kenneth. Regenerated cellulose structure and method of making same. U. S. pat. 2,952,550. Filed Oct. 15, 1956. 14 claims. Assigned to Tee-Pak, Inc. [Cl. 99-176.] A sausage casing is formed of a sheet of paper containing regenerated cellulose.

Phillips, Leslie N. Moulding of synthetic resinous materials. U. S. pat. 2,952,040. Filed Nov. 10, 1953. 10 claims. Assigned to Natl. Research Devt. Corp. [Cl. 18-55.] A resin is provided which is of use in impregnating and laminating fiber felts.

Potter, Clifford S. Collapsible containers. U. S. pat. 2,952,379. Filed Sept. 12, 1955. 9 claims. [Cl. 220-6.] The container has a pallet base.

Rice, Paul M. Mandrel. U. S. pat. 2,952,418. Filed May 11, 1955. 7 claims. Assigned to Celanese Corp. of Am. [Cl. 242-72.1.] An improved mandrel is provided for supporting a paperboard tube for free rotation of the tube, so that yarn may be wound thereon.

Rosner, Frances L. Disposable garbage bag. U. S. pat. 2,952,381. Filed July 11, 1956. 9 claims. [Cl. 220-19.]

Ruck, Arthur L., Layne, Richard C., and Dennis, Ralph E. Processing for forming plastic binders. U. S. pat. 2,952,037. Filed Sept. 14, 1956. 7 claims. [Cl. 18-47.5.] A plastic device for use as a loose-leaf binder for paper sheets is formed.

Schneider, William S. Self closing dispensing container. U. S. pat. 2,952,394. Filed Jan. 27, 1958. 4 claims. [Cl. 229-17.] A tetrahedron-shaped paper container for liquids is provided, having a reclosable dispensing opening.

Schur, Milton O. Wrapping device. U. S. pat. 2,952,105. Filed Aug. 6, 1957. 10 claims. Assigned to Olin Mathieson Chemical Corp. [Cl. 53-32.] A length of paper is wrapped about a number of axially aligned cigarette filters.

Searle, Robert F. Multiwall bag construction. U. S. pat. 2,952,399. Filed July 5, 1955. 3 claims. Assigned to Arkell and Smiths. [Cl. 229-66.] A line of weakening is provided to facilitate opening the bag.

Spees, Arthur T. Tear tape. U. S. pat. 2,952,395. Filed Oct. 21, 1957. 14 claims. [Cl. 229-51.] A package is completely sealed even though an end of the tear tape projects for easy grasping.

Steen, Harford K. Shopping bag. U. S. pat. 2,952,396. Filed Aug. 6, 1957. 2 claims. Assigned to Interstate Bag Co., Inc. [Cl. 229-54.] A shopping bag is provided with a waxed paper liner.

Tillman, Richard M. Method of curing concrete. U. S. pat. 2,952,062. Filed Sept. 9, 1957. 7 claims. Assigned to Continental Oil Co. [Cl. 25-154.] Rosin is employed in formulating a surface coating for wet concrete.

Ullman, Seymour. Coin counter. U. S. pat. 2,952,108. Filed March 14, 1958. 3 claims. [Cl. 53-254.] A device for counting coins into stacks is designed to facilitate moving each stack into a paper wrapper.

Watts, Sherman S. Pile elevating mechanism. U. S. pat. 2,952,458. Filed June 5, 1959. 37 claims. Assigned to Harris-Intertype Corp. [Cl. 271-62.] A pile-elevating mechanism of the type used in sheet feeders is designed to provide more automatic operation.

Whitlaw, Robert, and Field, Ventris E. Wound dressings. U. S. pat. 2,952,354. Filed Nov. 6, 1958. 6 claims. [Cl. 206-63.2.] A rolled and wrapped bandage is placed in a carton, so that it may be easily removed and unwrapped.

Yokose, Kyohei. Insulated conductor for communication cables and the manufacturing method of the same. U. S. pat. 2,952,728. Filed March 21, 1956. 3 claims. Assigned to Sumitomo Elec. Inds., Ltd. [Cl. 174-28.] The insulation is paper which is impregnated or coated with rubber or a resin such as polyethylene.

Sept. 20, 1960

Anderson, Carl E. Dispensing carton. U. S. pat. 2,953,293. Filed March 21, 1957. 6 claims. [Cl. 229-51.] An improved dispensing slot is provided in a carton for dispensing facial tissues.

Bergstedt, Milton A., and Young, Kenneth C. Pressure sensitive adhesive tape. U. S. pat. 2,953,475. Filed March 11, 1955. 12 claims. Assigned to Johnson & Johnson. [Cl. 117-72.] The tape is paper-backed and hydrocarbon solvent-resistant.

Bertschinger, Charles F. Tape dispenser. U. S. pat. 2,953,274. Filed Oct. 13, 1958. 10 claims. Assigned to Chart-Pak, Inc. [Cl. 216-20.] The device simultaneously dispenses several strips of tape which may be of different widths.

Cella, Joseph F. Apparatus for depositing paper containers in crates. U. S. pat. 2,953,407. Filed Oct. 5, 1956. 8 claims. Assigned to Cella Machinery, Inc. [Cl. 294-94.] Paper milk cartons are cased.

Chase, Henry V., Jr., and Foster, John C. Metal end for explosive cartridge and cartridge containing same. U. S. pat. 2,953,093. Filed Aug. 22, 1956. 7 claims. Assigned to Hercules Powder Co. [Cl. 102-24.] The body of the cartridge is formed of an inner wound manila paper layer and an outer laminated asphalt paper layer.

Dudley, Edward F. Chain delivery mechanism. U. S. pat. 2,953,089. Filed April 1, 1958. 6 claims. Assigned to Miehle-Goss-Dexter, Inc. [Cl. 101-272.] The sheet-delivery apparatus for a printing press moves the sheet at an initially high speed, then decelerates it as it approaches the delivery station.

Dunning, Robert M. Method and apparatus for folding carton flaps. U. S. pat. 2,953,070. Filed July 11, 1958. 6 claims. Assigned to Waldorf Paper Prods. Co. [Cl. 93-49.]

Francis, Carleton S., Jr. Fiber-mixing and fabricating apparatus. U. S. pat. 2,953,187. Filed July 20, 1948. 6 claims. Assigned to Am. Viscose Corp. [Cl. 154-29.] Different types of fibers are mixed by blowing in a closed chamber and are then air laid to form a mat.

Gray, Alfred E., Malin, Herman J., and Thompson, Harold B. Card processing apparatus. U. S. pat. 2,953,370. Filed April 13, 1959. 15 claims. Assigned to Magnavox Co. [Cl. 271-4.] Means are provided for feeding or stacking cards in a business machine.

Green, Frank B. K. Continuous digester. U. S. pat. 2,953,202. Filed July 15, 1955. 11 claims. Assigned to Pandia, Inc. [Cl. 162-237.] The horizontal tubes of the digester include sections for presteaming, impregnating, and cooking the chips.

Hartle, Cloyd U., and Moore, William F. Means for transmitting tickets by facsimile. U. S. pat. 2,952,930. Filed March 28, 1957. 2 claims. Assigned to Western Union Telegraph Co. [Cl. 40-10.] An assembly of paperboard and plastic is used as the transmitting blank, with the image being received on electrosensitive recording paper.

Harvey, Mortimer T., and Rosamilia, Peter L. Glass fibers coated with acetone-formaldehyde reaction products. U. S. pat. 2,953,478. Filed Oct. 1, 1956. 7 claims. Assigned to Harvel

Research Corp. [Cl. 117-126.] The reaction products are sizing or binding agents applied during or after the fibers have been formed into a mat.

Heuer, Kurt, Elling, Hugo, and Elssner, Richard. Production of shaped objects from viscose. U. S. pat. 2,953,425. Filed Oct. 17, 1955. 4 claims. Assigned to America Enka Corp. [Cl. 18-54.] Certain complex metal compounds are added to viscose to improve the resilience and degree of swelling of rayon filaments spun therefrom.

Heyden, Rudi, and Wedell, Hans. Waterproofing process and the article produced thereby. U. S. pat. 2,953,479. Filed Dec. 5, 1956. 9 claims. Assigned to Böhme Fettchemie G.m.b.H. [Cl. 117-135.5.] Paper and other fibrous materials are waterproofed with organic metal complexes.

Heywood, Vincent E. Manufacture of window envelopes. U. S. pat. 2,953,071. Filed April 16, 1956. 7 claims. Assigned to United States Envelope Co. [Cl. 93-61.]

Horton, Earl A. Carton upending device. U. S. pat. 2,953,-268. Filed Feb. 18, 1959. 5 claims. Assigned to The Yale and Towne Mfg. Co. [Cl. 214-652.] A fork-lift truck is provided with means for turning a large carton from the vertical to the horizontal.

Huck, William F. Resilient bearers. U. S. pat. 2,953,291. Filed Nov. 15, 1957. 9 claims. Assigned to Huck Co. [Cl. 226-153.] Improved web-feeding means are provided in an apparatus for cutting, folding, or otherwise processing web materials.

Landau, Raphael. Photosensitive materials. U. S. pat. 2,953,471. Filed Dec. 4, 1957. 6 claims. Assigned to Societe Alsacienne de Papiers Heliographiques. [Cl. 117-34.] A metal fluoride is applied to diazotype paper to improve image density.

Leichenich, Hans J., and Abendroth, Werner. Bottle packing machine. U. S. pat. 2,952,955. Filed July 7, 1958. 3 claims. Assigned to Niehler Maschinenfabrik. [Cl. 53-61.] A bottle casing machine is described.

Luczek, Walter, and Roberts, Franklin B. Suction means for wrapping instrumentalities. U. S. pat. 2,952,957. Filed Feb. 13, 1958. 9 claims. Assigned to Package Machinery Co. [Cl. 53-228.]

McCall, Richard J. Chipboard box. U. S. pat. 2,953,292. Filed Feb. 9, 1959. 1 claim. [Cl. 229-16.] Improved means are provided for locking the various flaps of a box into place.

Newman, Douglas A. Planographic printing. U. S. pat. 2,953,088. Filed March 25, 1957. 3 claims. Assigned to Columbia Ribbon and Carbon Mfg. Co., Inc. [Cl. 101-149.2.] A low-cost paper plate is provided for planographic printing in business systems.

Nigrelli, Biagio J., Standley, Wendell E., Wittmann, Richard B., and Snyder, Burton K. Package conveyor. U. S. pat. 2,953,240. Filed July 10, 1957. (Divided; original filed May 9, 1956.) 1 claim. Assigned to Johns-Nigrelli-Johns. [Cl. 198-179.] The conveyor holds and moves open-end can-carrier cartons while the cartons are being loaded.

Perrin, Phillip G. Packaging machine. U. S. pat. 2,952,954. Filed March 25, 1957. 47 claims. [Cl. 53-35.] Flat bags are fed from a supply stack, opened, filled, and sealed.

Piazze, Thomas E. Container filling and closing machine. U. S. pat. 2,952,959. Filed May 20, 1957. 13 claims. Assigned to Continental Can Co., Inc. [Cl. 53-266.] Bags are filled, closed, and sealed.

Purington, Paul G. Filing containers. U. S. pat. 2,953,246. Filed May 16, 1957. 2 claims. Assigned to The Shaw-Walker Co. [Cl. 206-79.] A file card includes a pocket for storing a folded paper tape.

Roshon, Carl T. Standing supports for collapsible retaining sheets employing flanged metal pallet legs. U. S. pat. 2,953,339. Filed Oct. 16, 1958. 5 claims. Assigned to Crown Zellerbach Corp. [Cl. 248-120.] Improved means are provided for affixing metal legs to a paperboard deck to form a pallet.

Rossin, Elmer H., and Scott, Milton J. Fire-retardant cellulosic compositions and process for producing fire-retardant cellulosic structures therefrom. U. S. pat. 2,952,880. Filed Dec. 14, 1956. (Divided; original filed June 30, 1951.) 9 claims. Assigned to Monsanto Chem. Co. [Cl. 18-57.]

Rossin, Elmer H., and Scott, Milton J. Fire-retardant cellulosic compositions and process for producing fire-retardant cellulosic structures therefrom. U. S. pat. 2,953,464. Filed Dec. 14, 1956. (Divided; original filed June 30, 1951.) 9 claims. Assigned to Monsanto Chem. Co. [Cl. 106-15.] This is similar to U. S. pat. 2,952,880 (Sept. 20, 1960).

Scherber, Floyd I. Process of coating regenerated cellulose film with polyethylene and resultant article. U. S. pat. 2,953,482. Filed July 18, 1957. 8 claims. Assigned to E. I. du Pont de Nemours & Co. [Cl. 117-145.]

Schneider, Caspar C. Aqueous composition of melamine-formaldehyde resin, polystyrene and colloidal silica, and cellulosic body impregnated therewith. U. S. pat. 2,953,534. Filed Sept. 8, 1954. 4 claims. [Cl. 260-17.3.] The composition may be used for impregnating paper to provide heat and grease resistance.

Schürmann, Max-Otto. Aftertreatment of tows consisting of continuous artificial filaments. U. S. pat. 2,953,424. Filed Dec. 13, 1954. Assigned to Farbenfabriken Bayer A. G. [Cl. 8-151.2.] A tow of regenerated cellulose filaments is subjected to a liquid afterspinning treatment.

Smith, John G. Sheet feeder. U. S. pat. 2,953,371. Filed Dec. 31, 1957. 13 claims. Assigned to Burroughs Corp. [Cl. 271-26.] Single sheets are fed by a suction feeding system.

Talbot, Richard C., and Madden, Wayne S. Packaging machine. U. S. pat. 2,952,960. Filed March 29, 1956. 6 claims. Assigned to J. L. Ferguson Co. [Cl. 53-381.] A neat square closure secured by adhesive is formed at the end of a filled bag.

Theiler, Robert. Packing apparatus on a machine for producing blocks of kneadable material. U. S. pat. 2,952,958. Filed Nov. 15, 1957. 9 claims. Assigned to Alofin Verwaltungs- & Finanzierungs-A. G. [Cl. 53-230.] A freshly molded block of ductile material is placed on a wrapper and the wrapper is folded about the block.

Tierney, John B. Device for making pair comparisons. U. S. pat. 2,952,924. Filed Aug. 21, 1957. 6 claims. [Cl. 35-48.] An assembly of paper, board and plastic elements form a device of use in ranking the items of a group by a pair comparison method.

Treciokas, Jacob P. Envelop fastener machine. U. S. pat. 2,953,275. Filed Sept. 15, 1959. 4 claims. Assigned to Scovill Mfg. Co. [Cl. 218-6.] Snap fasteners are affixed to envelopes.

Welfers, Egidius. Production of shaped objects from viscose. U. S. pat. 2,953, 426. Filed Oct. 25, 1955. 1 claim. Assigned to American Enka Corp. [Cl. 18-54.] This is similar to U. S. pat. 2,953,468 (Sept. 20, 1960).

Welfers, Edigius. Production of shaped objects from viscose. U. S. pat. 2,953,468. Filed Oct. 21, 1959. (Divided; original filed Oct. 25, 1955.) 1 claim. Assigned to American Enka Corp. [Cl. 106-165.] In using monoamines as modifiers, greater operating range is achieved by also adding hydrazine.

Williams, Paul H., and Green, Albert J. Check aligning mechanism. U. S. pat. 2,953,372. Filed Aug. 26, 1957. 7 claims. Assigned to the Natl. Cash Register Co. [Cl. 271-52.] Pieces of record material are aligned for printing.

Zurheide, George B. Glass packaging and handling machine. U. S. pat. 2,953,233. Filed June 15, 1955. 23 claims. Assigned to Pittsburgh Plate Glass Co. [Cl. 198-21.] Interior packing members are positioned about sheets of glass and the assembly is inserted into a shipping carton.

Sept. 27, 1960

Azari, Eric, and Nelson, Alfred M. Card processing apparatus. U. S. pat. 2,954,226. Filed May 5, 1958. 21 claims. Assigned to the Magnavox Co. [Cl. 271-5.] Card-feeding means are provided in a business machine.

Bate, Stanley C., Peach, Francis G., and Rogerson, Walter A. Purification of cellulose. U. S. pat. 2,954,312. Filed Sept. 26, 1952. 7 claims. Assigned to British Celanese, Ltd. [Cl. 162-85.] Alkaline process pulp is purified in the manufacture of dissolving pulp.

Bell, Robert E. Label activator. U. S. pat. 2,954,455. Filed Aug. 13, 1958. 16 claims. Assigned to Toledo Scale Corp. [Cl. 219-19.] An apparatus is provided for heat-activating and dispensing labels.

Bennett, David. Collapsible boxes. U. S. pat. 2,954,153. Filed Jan. 2, 1959. 2 claims. Assigned to Modern Millinery Box Corp. [Cl. 229-41.] A polyhedral collapsible hatbox is provided with improved means for locking the box in erected condition.

Bruce, Donald S., and Heise, Howard L. Adhesive mixture containing polyvinyl alcohol, lignosulfonic acid and a migration inhibitor. U. S. pat. 2,954,353. Filed June 25, 1957. 2 claims. Assigned to St. Regis Paper Co. [Cl. 260-17.5.] The adhesive is for use in making nonblocking remoistenable gummed paper.

Buttery, Kenneth T., and Gilbert, Louis M. Display carton. U. S. pat. 2,954,151. Filed Nov. 10, 1954. 12 claims. Assigned to KVP Sutherland Paper Co. [Cl. 229-19.] A sleeve-and-slide display carton is provided for packing a slab of shingled bacon strips.

Buttery, Kenneth T., and Vanderlugt, Thomas, Jr. Collapsible polyhedral carton. U. S. pat. 2,954,152. Filed July 31, 1957. 1 claim. Assigned to KVP Sutherland Paper Co. [Cl. 229-39.] A carton for a whiskey bottle is provided with a collapsible display panel.

Clark, Harold E. Method for preparing a spirit duplicating master. U. S. pat. 2,954,291. 1 claim. Assigned to Haloid Xerox, Inc. [Cl. 96-1.] A paper-base spirit duplicating master is prepared by a xerographic process.

Dunwody, Archibald B. Process for cleaning and pulping waste. U. S. pat. 2,954,173. Filed Dec. 11, 1958. 6 claims. [Cl. 241-24.] The waste includes wastepaper and rags.

Ellison, Samuel H., Jr. Mechanical fruit counter. U. S. pat. 2,953,881. Filed Feb. 14, 1958. 14 claims. Assigned to

Food Machinery and Chemical Corp. [Cl. 53-78.] A predetermined number of pieces of fruit are counted into a packaging container.

Galloway, Robert K. Carton closure tab crimping device. U. S. pat. 2,953,884. Filed July 30, 1957. 17 claims. Assigned to Food Machinery and Chemical Corp. [Cl. 53-374.]

Galloway, Robert K. Carton feeding device. U. S. pat. 2,954,227. Filed June 18, 1956. 5 claims. Assigned to Food Machinery and Chemical Corp. [Cl. 271-34.] The apparatus feeds lightweight collapsed frozen food cartons without damaging them.

Gentry, Hermond G. Apparatus and method for automatically packaging articles in wrapper blanks. U. S. pat. 2,953,883. Filed June 4, 1957. 15 claims. Assigned to Mead Pkg., Inc. [Cl. 53-209.] A group of cans is wrapped in a paperboard blank to form an open-end six-pack assembly.

Goldsholl, Morton. Phonograph record envelope. U. S. pat. 2,954,119. Filed Nov. 8, 1957. 5 claims. [Cl. 206-62.]

Gorman, William S., Jr. Water repellant paper and sheathing board. U. S. pat. 2,954,302. Filed Dec. 10, 1956. 8 claims. Assigned to Natl. Gypsum Co. [Cl. 117-60.] Paper for sheathing gypsum board is treated with fuel oil to provide water repellency while retaining vapor permeability.

Hahn, Willard E. Method and apparatus for forming seams in multiwall bags. U. S. pat. 2,953,976. Filed Jan. 3, 1956. 9 claims. Assigned to St. Regis Paper Co. [Cl. 93-8.]

Heuser, Elliott G. Unitized protected label assembly. U. S. pat. 2,953,865. Filed May 22, 1959. 2 claims. Assigned to W. H. Brady Co. [Cl. 40-2.] A label assembly includes a sheet of labels with pressure-sensitive adhesive, a transparent cover sheet also adhesive coated, and a removable liner sheet between the two.

Karabinos, Joseph V., and Ballun, Aloysius T. Production of improved polyethenoxy esters and products derived therefrom. U. S. pat. 2,954,369. Filed June 30, 1953. 15 claims. Assigned to Olin Mathieson Chemical Corp. [Cl. 260-97.5.] The color of ethylene oxide condensates of tall oil is improved.

Lithio, Clarence N. Banding device for wrapping machines. U. S. pat. 2,954,069. Filed March 14, 1957. 11 claims. Assigned to Rapinwax Paper Co. [Cl. 154-1.6.] A paper-reinforcing and labeling band is applied to bread wrap before the wrapping operation.

Martin, Edward J. Composition of matter consisting of a microcrystalline wax and 5–25% of an aromatic petroleum extract U. S. pat. 2,954,337. Filed July 16, 1953. 4 claims. Assigned to Sinclair Refining Co. [Cl. 208-21.] The composition is for use in laminating sheets of paper for use in food packaging.

Maso, Henry F., and Masci, Joseph N. Rupturable seal package with sterilized moist contents. U. S. pat. 2,954,116. Filed May 6, 1957. 11 claims. Assigned to Johnson & Johnson. [Cl. 206-56.] Layers of kraft paper, polyethylene, aluminum foil, glassine, and a resin are assembled to form a flat pack for a sterile surgical dressing.

Mooney, Stuart. Combination circular and envelope. U. S. pat. 2,954,154. Filed Aug. 16, 1956. 1 claim. Assigned to Double Envelope Corp. [Cl. 229-70.]

Moore, Lawrence A. Paper machinery. U. S. pat. 2,954,082. Filed May 21, 1958. 9 claims. Assigned to the Black-Clawson Co. [Cl. 162-264.] A broke-disposing apparatus is provided.

Murray, Arthur J. Apparatus for packaging articles. U. S. pat. 2,953,879. Filed Feb. 8, 1955. 2 claims. Assigned to Stramur Corp. [Cl. 53-48.] A six-pack of cans is formed.

Novick, Abraham. Feeding mechanism for envelopes and the like. U. S. pat, 2.954,225. Filed Dec. 3, 1956. 7 claims. Assigned to F. L. Smithe Machine Co., Inc. [Cl. 271-1.] Means are provided to feed envelope blanks from the bottom of a supply stack into fanned-out relation.

Saffir, Jacob A. Cigarettes. U. S. pat. 2,954,035. Filed April 4, 1958. 11 claims. [Cl. 131-10.] Means are provided to regulate the amount of filtering action provided by a cigarette filter.

Schur, Milton O. Method and apparatus for making filter rods. U. S. pat. 2,953,878. Filed Dec. 23, 1957. 9 claims. Assigned to Olin Mathieson Chemical Corp. [Cl. 53-28.] The apparatus described assembles a multi-element cigarette filter and secures a paper tape wrapping about the assembly.

Schur, Milton O., and Rickards, James C. Cellulosic sheet and filter, and process therefor. U. S. pat. 2,954,036. Filed June 3, 1958. 11 claims. Assigned to Olin Mathieson Chemical Corp. [Cl. 131-208.] A method of making a cigarette filter is described.

Sheeran, Norman J. Laminating adhesive and method of producing the same. U. S. pat. Re. 24,881. Filed April 27, 1959. (Original filed Jan. 20, 1959.) 11 claims. Assigned to Am.-Marietta Co. [Cl. 106-124.] The adhesive includes blood, kaolin, and sodium hydroxide.

Sramek, Elmer D., and Vogel, Walter H. Wrapping machine. U. S. pat. 2,953,880. Filed Sept. 2, 1958. 10 claims. Assigned to F. B. Redington Co. [Cl. 53-73.] The wrapping sheet feeding operation is stopped when no articles are fed to be wrapped.

Tew, Gilbert W. Packaging machine. U. S. pat. 2,953,882. Filed May 8, 1959. 10 claims. Assigned to Sperry Rand Corp. [Cl. 53-126.] A machine is provided for carrying out the continuous, forming, filling, and sealing of bags.

Whelan, James P. Infusion bag. U. S. pat. 2,954,294. Filed May 17, 1957. 4 claims. Assigned to Pneumatic Scale Corp., Ltd. [Cl. 99-77.1.] An improved nontangling tag and handle arrangement is provided.

Woodward, Eugene E. Sizing fibrous cellulosic materials. U. S. pat. 2,954,313. Filed Oct. 17, 1955. 11 claims. Assigned to Kerr-McGee Oil Industries, Inc. [Cl. 162-171.] The size is a bitumen-in-water emulsion prepared using certain emulsifying agents such as tall oil.

The following patents were received later than those of the same issue date and have accumulated during the past quarter.

July 28, 1959

Ramén, Torsten. Evaporation of liquids. U. S. pat. 2,896,705. Filed March 23, 1956. 3 claims. [Cl. 159-47.] The heat economy of a multistage evaporation system for spent sulfite liquor is improved.

Nov. 24, 1959

Kartinos, Nicholas J., and Williams, William W. Fluorescent methine dyes. U. S. pat. 2,914,551. Filed Sept. 5, 1956. 4 claims. Assigned to General Aniline & Film Corp. [Cl. 260-465.] The dye is of use in coating paper and coloring cellulosic materials.

Jan. 5, 1960

Strandberg, Carl H. Film frame or slide packaging box and viewer. U. S. pat. 2,919,509. Filed Jan. 31, 1958. 5 claims. [Cl. 40-63.] A carton for photo transparencies may also be used as a viewer.

Feb. 2, 1960

Jursich, Myron J. Antifoam compositions and uses thereof. U. S. pat. 2,923,687. Filed Dec. 10, 1956. 10 claims. Assigned to Nalco Chem Co. [Cl. 252-321.] These compositions are for use in papermaking systems.

Feb. 23, 1960

Keim, Gerald I. Cationic thermosetting polyamide-epichlorohydrin resins and process of making same. U. S. pat. 2,926,154. Filed March 3, 1959. 16 claims. Assigned to Hercules Powder Co. [Cl. 260-29.2] A paper wet-strength agent is provided.

Lerch, Robert L. Plastic asbestos tile containing rosin-ester modified phenol-formaldehyde resin and a vinyl resin. U. S. pat. 2,926,150. Filed May 1, 1957. 3 claims. Assigned to Armstrong Cork Co. [Cl. 260-19.]

March 1, 1960

Reeves, Wilson A., and Guthrie, John D. Flameproofing of wood. U. S. pat. 2,927,050. Filed Sept. 3, 1953. 2 claims. [Cl. 154-133.] The agent is a polymer made by reacting tetrakis(hydroxymethyl)phosphonium chloride with acrylamide.

March 15, 1960

Newburg, Raymond G., Miller, Alfred L., and McCulloch, William J. G. Isoolefin-vinyl aromatic copolymer latex containing an organic anionic sulfate and a salt of a dihydrogen orthophosphate. U. S. pat. 2,928,759. Filed Feb. 27, 1957. 18 claims. Assigned to Esso Research and Eng. Co. [Cl. 117-113.] The composition is for paper coating to provide a moisture barrier.

March 22, 1960

Stevens, John A. Gas treatment device. U. S. pat. 2,929,761. Filed May 20, 1957. 5 claims. Assigned to Paper Prods., Inc. [Cl. 167-39.] A paper sheet is coated in spaced areas with chemicals which react when the paper is folded to bring them together, so as to produce ammonia for retarding mold on fruit near which the paper is placed.

April 19, 1960

Segerstrom, Henry C., and Andrews, Walter J. Carton sealing machine. U. S. pat. 2,932,927. Filed July 18, 1958. 9 claims. Assigned to International Paper Co. [Cl. 53-64.] A telescoping cover carton is sealed about a stack of paper sheets, with the sheets being compacted and air removed therefrom.

Toulmin, Harry A., Jr. Printing pastes. U. S. pat. 2,933,403. Filed Feb. 13, 1957. 2 claims. Assigned to The Commonwealth Engineering Co. of Ohio. [Cl. 106-22.]

May 3, 1960

Sayko, Andrew F., and Newberg, Raymond G. Asphalt, isobutylenestyrene copolymer, hydrocarbon oil adhesive for laminates. U. S. pat. 2,935,486. Filed July 5, 1955. 5 claims. Assigned to Esso Research and Engineering Co. [Cl. 260-28.5.]

May 10, 1960

Rapson, William H. Production of chlorine dioxide. U. S. pat. 2,936,219. Filed Feb. 18, 1957. 4 claims. Assigned to Hooker Chemical Corp. [Cl. 23-152.]

Schmid, Max, and Mueller, Willy. Azo-dyestuffs. U. S. pat. 2,936,306. Filed May 8, 1958. 8 claims. Assigned to Ciba, Ltd. [Cl. 260-176.] The dyes are for use on cellulosic materials.

May 17, 1960

Casse, Marcel. Method of manufacturing blanks of articles of felt and automatic machine therefor. U. S. pat. 2,936,512. Filed May 3, 1955. 22 claims. [Cl. 28-72.3.] Fibers are felted together on a perforated shaped support.

Earp, James F. Container blank feeder mechanism. U. S. pat. 2,936,681. Filed Jan. 30, 1957. 9 claims. Assigned to Ex-Cell-O Corp. [Cl. 93-53.] Collapsed gable-top milk cartons are fed from a supply magazine to an erecting means.

Maguire, Richard G., and Hedrick, Glen W. Color reaction type duplication process. U. S. pat. 2,936,707. Filed June 22, 1951. 2 claims. Assigned to Ditto, Inc. [Cl. 101–149.4.]

May 24, 1960

Mitchell, Reid L., Berry, James W., and Wadman, William H. Viscose process. U. S. pat. 2,937,922. Filed March 24, 1954. 5 claims. Assigned to Rayonier, Inc. [Cl. 18-54.] All skin rayon filaments are formed.

May 31, 1960

Eichorn, Robert N. Container. U. S. pat. 2,938,623. Filed April 30, 1957. 6 claims. Assigned to International Business Machines Corp. [Cl. 206-60.] A carton is provided for packing tabulating cards for business machines.

June 7, 1960

Amphlett, Philip H., Dundas, James, and Woodthorpe, Geoffrey L. H. Treatment of fibrous materials with coating or impregnating agents. U. S. pat. 2,939,814. Filed Jan. 31, 1956. 5 claims. Assigned to Jointine Prods. Co., Ltd. [Cl. 162-182.] A variety of substances are coated onto paper-making fibers by first coating the fibers with a polyvinyl alkyl ether.

Royce, Mark B. Folding container with slip-in veneers. U. S. pat. 2,939,620. Filed Dec. 2, 1958. 1 claim. Assigned to Continental Can Co., Inc. [Cl. 229-14.] A windowed produce-shipping container is provided with reinforcing frames.

Wayman, Morris, and Harris, Gordon R. Pulping of lignocellulosic material. U. S. pat. 2,939,813. Filed April 25, 1956. 6 claims. Assigned to Columbia Cellulose Co., Ltd. [Cl. 162-78.] The pulping agent used is peracetic acid.

Wilson, Roy K. Dome pack container. U. S. pat. 2,939,-624. Filed Dec. 19, 1956. 7 claims. Assigned to St. Joe Paper Co. [Cl. 229-43.] A produce shipping carton has a lid which has a flat exterior and a domed interior.

June 14, 1960

Heritage, Clark C. Continuous deposition of dry felted structures. U. S. pat. 2,940,133. Filed April 14, 1950. 15 claims. Assigned 50% to Weyerhaeuser Co., and 50% to Wood Conversion Co. [Cl. 19-156.] A method of air-laying a fiber web is described.

Heritage, Clark C. Dry felting apparatus and process. U. S. pat. 2,940,134. Filed Sept. 2, 1950. 21 claims. Assigned 50% to Weyerhaeuser Co., and 50% to Wood Conversion Co. [Cl. 19-156.] A process for air-laying fibers to form a felt is provided with means for recovering lost fiber fines.

Swedish, Frank, Jr., O'Brien, William H., and Picard, Lloyd E. Masking tape. U. S. pat. 2,940,591. Filed Aug. 22, 1958. 3 claims. Assigned to Minnesota Mining and Mfg. Co. [Cl. 206-59.] The paper backing is made from semiglassine wet-creped paper made from highly beaten fibers.

Welfers, Egidius. Production of shaped objects from viscose. U. S. pat. 2,940,818. Filed Oct. 25, 1955. 1 claim. Assigned to Am. Enka Corp. [Cl. 18-54.] Filaments with improved resilience and degree of swelling are formed.

June 21, 1960

Fleissner, Gerold. Apparatus for producing a uniform bat of fibrous material. U. S. pat. 2,941,264. Filed March 16, 1959. 3 claims. Assigned to Fleissner & Sohn Maschinenfabrik. [Cl. 19-156.] Improved provision for suction is provided in a needle drum apparatus for forming a bat of fibrous material.

Hoffman, Frank E. Process for treating film. U. S. pat. 2,941,255. Filed Sept. 14, 1955. 1 claim. Assigned to E. I. du Pont de Nemours and Co. [Cl. 18-57.] A traveling web of cellophane is reciprocated transversely so that irregularities are not superposed when the film is wound.

Picard, Lloyd E., and Swedish, Frank, Jr. Masking tape. U. S. pat. 2,941,661. Filed Feb. 24, 1959. 2 claims. Assigned to Minnesota Mining and Mfg. Co. [Cl. 206-59.] A kraft saturating paper for fine-creping and use in masking tape is formed from a furnish including deacetylated karaya gum.

June 28, 1960

Arledter, Hanns F. High ash content absorbent paper for the decorative laminating industry and a process for preparing the same. U. S. pat. 2,943,013. Filed July 27, 1956. 13 claims. Assigned to Hurlbut Paper Co. [Cl. 162-157.]

Austin, Thomas W. Heat sealable thermoplastic film. U. S. pat. 2,943,000. Filed March 27, 1958. 7 claims. Assigned to Dow Chemical Co. [Cl. 117-72.] A coated ethylcellulose film is prepared.

Burgwald, Theodore, Linsk, Jack, and Morello, Edwin F. Stable gas-generating composition. U. S. pat. 2,942,964. Filed April 26, 1955. 8 claims. Assigned to Standard Oil Co. [Cl. 52-.5.] Cellulose acetate is used in compounding a rocket propellant.

Burgwald, Theodore A. Solid propellant combustion catalyst. U. S. pat. 2,942,963. Filed Feb. 7, 1955. 7 claims. Assigned to Standard Oil Co. [Cl. 52-.5.] Cellulose acetate and cellulose acetate butyrate are used in compounding a rocket fuel.

Dunning, John W., Moses, Alexander K., Jr., and Terstage, Robert J. Method and apparatus for fiberizing fibrous material. U. S. pat. 2,943,012. Filed Dec. 1, 1955. 14 claims. Assigned to International Basic Economy Corp. [Cl. 162-18.]

Eichorn, Robert N. Carton. U. S. pat. 2,942,770. Filed Dec. 20, 1957. 5 claims. Assigned to Intern. Business Machines Corp. [Cl. 229-33.] A carton for business machine cards is designed to have a variable length.

Eiszner, James R., and Stanley, William G. Rocket propellant. U. S. pat. 2,942,961. Filed Dec. 23, 1954. 12 claims. Assigned to Standard Oil Co. [Cl. 52-.5.] This is similar to U. S. pat. 2,942,964 (June 28, 1960).

Kelly, Daniel R. Aluminum brightener compositions. U. S. pat. 2,942,956. Filed Oct. 13, 1958. 18 claims. Assigned to Wyandotte Chemicals Corp. [Cl. 41-42.] Methylcellulose is used.

Laden, Max H. Non-tear case sealing adhesive. U. S. pat. 2,943,071. Filed Dec. 8, 1954. 5 claims. Assigned to Swift & Co. [Cl. 260-27.]

Langseth, Axel O. Artificially colored roofing granules. U. S. pat. 2,943,002. Filed May 11, 1959. 3 claims. Assigned to Minnesota Mining and Mfg. Co. [Cl. 117-100.]

Mitchell, Reid L., Berry, James W., and Wadman, William H. Viscose process. U. S. pat. 2,942,931. Filed May 5, 1959. 6 claims. Assigned to Rayonier, Inc. [Cl. 18-54.] The coagulation modifier used is a mixture of polyethylene glycol and dimethylamine.

Morello, Edwin F., and Proell, Wayne A. Stable rocket propellant. U. S. pat. 2,942,962. Filed Jan. 12, 1955. 8 claims. Assigned to Standard Oil Co. [Cl. 52-.5.] This is similar to U. S. pat. 2,942,964 (June 28, 1960).

Nelson, Permil N. Chuck for paper rolls. U. S. pat. 2,942,-892. Filed May 8, 1956. 2 claims. Assigned to Lynn H. Ewing. [Cl. 279-2.] An expansible chuck is provided for supporting a hollow core paper roll on a shaft.

Proell, Wayne A., and Bowman, Norman J. Thermoplastic compositions. U. S. pat. 2,942,994. Filed Oct. 27, 1954. 9 claims. Assigned to Standard Oil Co. [Cl. 106-178.] Various cellulose derivatives are plasticized with nitrodiphenyl ethers.

Twelfth

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May 8–10, 1961

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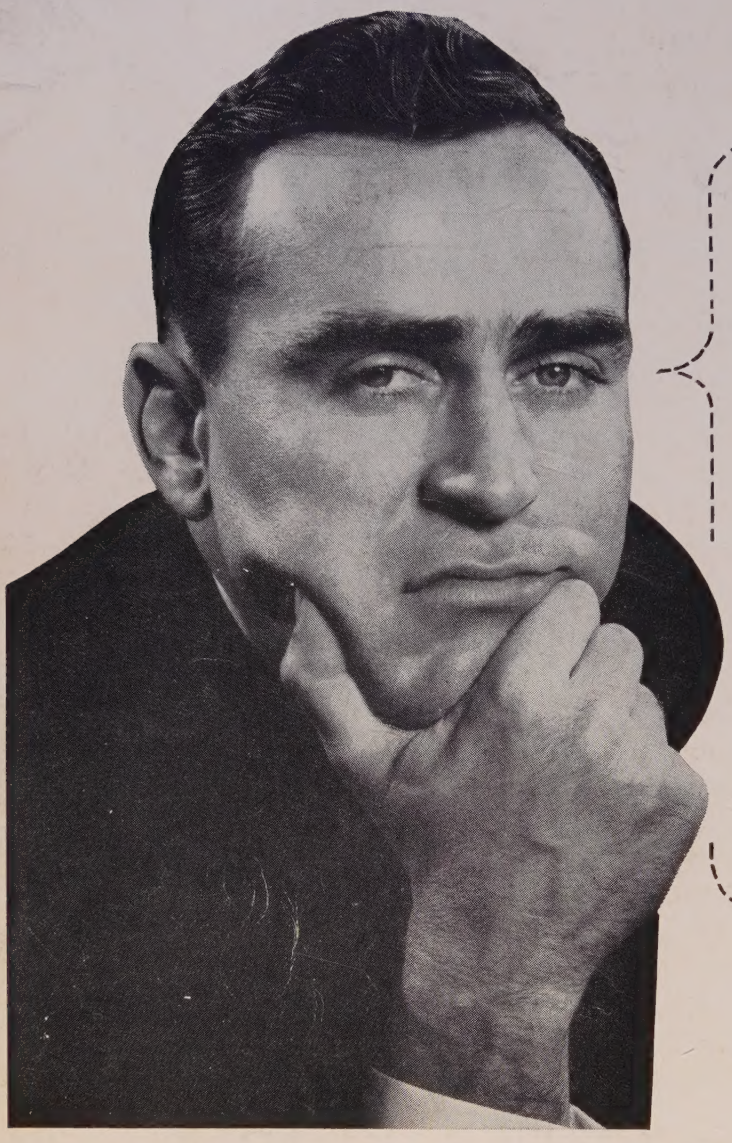
Thinking of coating or filling with clay?



Should we use a trailing blade... or an air knife?

Maybe it should be a roll coater... or a reverse roll?

What about a size press?

Double coating? Simultaneous or successive?

On or off the machine?

Wet or dry storage?

Fill at the secondary headbox?

Best place to furnish the clay?

There are plenty of tough decisions to make when it comes to coating or filling paper with clay. Using clay successfully involves a lot more than selecting a grade.

You'll find the Georgia Kaolin Company furnishes a lot more than just quality clay. The important extra is technical service. Georgia Kaolin has helped many companies, large and small, in solving problems of clay handling, clay make-down and coating-color formulation.

Georgia Kaolin technical assistance goes beyond ideas and opinions. The Sales Service Department operates pilot coating machines which can demonstrate the effects, on your own raw stock, of different formulations and various methods of coating. These facilities, plus Georgia Kaolin knowledge and skill, can be an all-important adjunct to your own research.

START BY CONTACTING US.

Georgia Kaolin Company 433 North Broad St., Elizabeth, N. J.

Fine clays from the world's largest kaolin plant